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Pacific Environmental Services, Inc, Santa Monica, Calif

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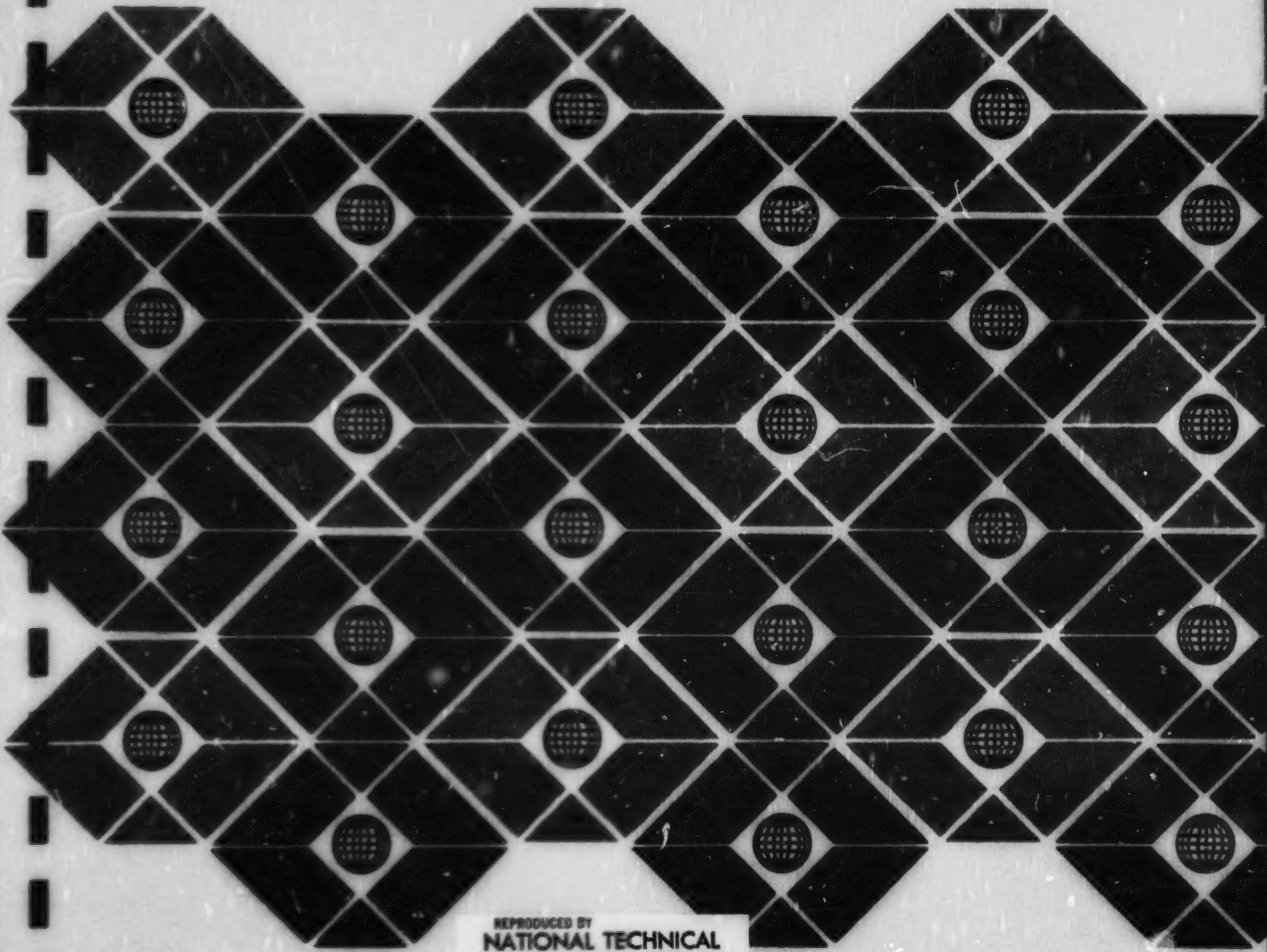
STUDY OF GASOLINE VAPOR EMISSION CONTROLS

Contract No. 68-01-3156, Task Order No. 15

Prepared for:

U.S. Environmental Protection Agency
Enforcement Division
Region VIII
Denver, Colorado

December 1976



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The purpose of this report is to provide information to operators of gasoline bulk plants and to air pollution control authorities regarding sources of emissions of hydrocarbon vapors from bulk plants and the effectiveness and costs of available technology for control of these emissions. The study was limited to bulk plants distributing less than 76,000 liters (20,000 gallons) of gasoline daily. Pacific Environmental Services, Inc., under an EPA contract, conducted an independent evaluation of the impact of hydrocarbon emission controls on bulk plants. PES developed a data base from a survey of bulk plants in three Air Quality Control Regions. Data base was used to define a typical bulk plant operation and estimate the uncontrolled hydrocarbon emissions. Results indicated that the typical bulk plant is small (15,000 liters or 4,000 gallons per day) and that breathing and fugitive emissions are significant factors in addition to transfer emissions which EPA regulations control. PES surveyed available hydrocarbon emission control techniques, investigating the most promising techniques for cost, efficiency, development status and bulk plant applicability.

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PREFACE

The purpose of this report is to provide information to operators of gasoline bulk plants and to air pollution control authorities regarding sources of emissions of hydrocarbon vapors from bulk plants and regarding effectiveness and costs of available techniques for control of these emissions. The study was limited to bulk plants distributing less than 76,000 liters (20,000 gallons) of gasoline daily.

ABSTRACT

Pacific Environmental Services, Inc. (PES), under an Environmental Protection Agency (EPA) contract, conducted an independent evaluation of the impact of hydrocarbon emission controls on bulk plants. PES developed a data base from a survey of bulk plants in three Air Quality Control Regions (AQCR's). Data base was used to define a typical bulk plant operation and estimate the uncontrolled hydrocarbon emissions. Results indicated that the typical bulk plant is small (15,000 liters or 4,000 gallons per day) and that breathing and fugitive emissions are significant factors in addition to transfer emissions which EPA regulations control.

PES surveyed available hydrocarbon emission control techniques with respect to bulk plant application. Most promising techniques were investigated for cost, efficiency, development status and bulk plant applicability. Most promising techniques appear to be balance systems, two types of secondary (processing) systems, submerged fill and a limited increase in operating tank pressure. Submerged fill and limited tank operating pressure increase are inexpensive, require little development and few application difficulties are expected, but control efficiency is expected to be less than 90%. Balance systems and secondary systems can have good efficiencies, require moderate development and few application difficulties are expected, but cost may be high. Key factor in total costs is the potential conversion of the plant loading facilities from top- to bottom-loading. The validity of including this cost in hydrocarbon control costs is uncertain.

Model and efficiency analysis indicates that the critical factor for attaining good efficiency in a balance system is prevention of leakage. Efficiency of a secondary (processing) system is dependent upon specific equipment design and application. Control of fugitive emissions is primarily a function of maintenance.

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1. INTRODUCTION

The Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards for hydrocarbons and for photochemical oxidants. Hydrocarbon emissions are significant primarily because of their potential for increasing photochemical oxidants. As a part of the effort required to maintain these standards the EPA has promulgated regulations intended to control emission of vapors during transfer of gasoline in 13 Air Quality Control Regions (AQCR's). In addition, several local agencies control emissions using similar regulations. These regulations apply to many types of distributors and users, including bulk plants which distribute gasoline.

Pacific Environmental Services, Inc. (PES), under EPA Region VIII, Contract No. 68-01-3156, Task No. 15, conducted an independent evaluation of the impact of hydrocarbon emission controls (vapor recovery) on bulk plants. The results of this study are documented in this report and summarized in Section 2. The study was limited to bulk plants distributing gasoline at less than 76,000 liters (20,000 gallons) per day. This limit allows analysis of the large majority of all bulk plants while avoiding the confusion of the few large plants. For this study, a bulk plant was defined as a petroleum storage facility, receiving and distributing products by truck. San Diego (California), San Joaquin Valley (California), and Denver (Colorado) AQCR's were selected for detailed investigation.

A comprehensive inventory of gasoline bulk plants was prepared for the three AQCR's. Inventory lists, by county, are documented in Appendix A.* In addition to identification of the numbers and locations of affected bulk plants, a large amount of additional information was sought. A sample telephone checklist is shown in Appendix B and was used only when other sources of data were not adequate.

The Metropolitan Denver Air Quality Control Region comprises Denver City and County and seven surrounding counties. In three of these counties, namely Clear Creek, Douglas and Gilpin, no bulk plants were located.

Many sources of information were consulted to compile these inventory lists as well as to obtain additional information. Sources, other than bulk plant operators, who were contacted for information are listed in Appendix C.

Bulk plant information from these sources included gasoline throughput, storage tank parameters, descriptions of hardware and systems used in gasoline transfer, transfer flow rates, plumbing line sizes and lengths, account truck parameters, costs of vapor control equipment, operational times and modes, and customer types. The information sought was directed at (1) defining typical bulk plants for a baseline and (2) evaluating the impact of vapor recovery regulations and systems on the operations and economics of bulk plants.

Typical bulk plants and their operations are described in Section 3. Descriptions are based on the mean of all the data, except where discontinuities were observed, such as underground versus aboveground storage tanks. Range is also presented for data items with especially large variations.

Hydrocarbon emission sources are identified and discussed in Section 4. The applicability and accuracy of published emission factors for vapor losses at bulk plants is evaluated. The parameters affecting these emissions are reviewed.

Section 5 reviews hydrocarbon control techniques in use or available. These alternatives are evaluated for efficiency, cost, technical development required and applicability to bulk plants. The most promising alternatives or combinations of alternatives for application at a typical plant are indicated. Applicable regulations are discussed in Appendix E.

Section 6 discusses cost estimates for selected control alternatives, as obtained from operators, contractors, manufacturers, and major oil companies. Differences between estimates are reviewed. Appendix D reviews contractor supplied data.

Theoretical models of selected control alternatives are developed in Section 7 to provide means of estimating controlled emissions. Control efficiency of these alternatives are also discussed.

Section 8 presents the conclusions of this study. These include: typical bulk plant description, uncontrolled emissions, selected control alternatives with corresponding efficiency and cost, and areas for future effort.

2. SUMMARY

An inventory of over 250 bulk plants in San Diego (California), San Joaquin Valley (California) and Denver (Colorado) Air Quality Control Regions was generated. A typical bulk plant, based on this inventory, would be an old storage facility at the edge of a town, having three fixed-roof, above-ground tanks used for gasoline storage. Its gasoline throughput would be 15,000 liters (4,000 gallons) per day, delivered by tank trucks (with trailers) hauling loads of 34,000 liters (9,000 gallons), and dispatched in top-loaded tank trucks, primarily to small agricultural accounts. A slowly growing minority, about 25 percent, of the bulk plants inventoried, utilize underground (rather than above-ground) storage tanks.

Uncontrolled hydrocarbon emissions from bulk plants are classified as breathing, working and fugitive losses. Breathing losses are significant because the typical bulk plant uses low pressure above-ground fixed-roof storage tanks. Breathing losses are primarily caused by daily temperature changes which alternately expel air laden with hydrocarbon vapors during the day and draw in fresh air at night. Typical breathing loss is estimated to be 9.1 kg (20 lb) per day. Working losses are primarily caused by the displacement of air-hydrocarbon vapors by liquid during refilling of tanks. Typical working losses are estimated to be 17 kg (37.5 lb) per day. Fugitive losses are caused primarily by spillage and leakage of gasoline liquid and vapors. The losses are highly variable, since they depend upon maintenance and operator care. Little data is available, but fugitive emissions are estimated to be in the order of 6 kg (13 lb) per day. (These estimates correspond to the typical bulk plant described above.)

Systems to control hydrocarbon emissions can be classified by the type of emissions primarily controlled. Submerged fill, balance systems and secondary (processing) systems have been applied to bulk plants and service stations to control working losses. Pressurized tanks and secondary systems have been applied to bulk plants to control breathing losses.

The three common techniques for control of working losses, namely, submerged fill, balance systems and secondary systems, are progressively more costly, but also more efficient. Submerged fill (extension of the delivery of nozzle to a point below the liquid surface) is inexpensive but cannot achieve 90 percent control of working losses. Balance systems can achieve 90 percent control of working losses (this degree of control is required by EPA gasoline transfer vapor control regulations) but initial facility costs are expected to average about $20,000, to which may be added truck modification costs of $4,000 per truck. Facility costs seem primarily due to converting to bottom-loading from top-loading. Although conversions may be caused by vapor recovery regulations, other benefits, such as improved safety and modernized facility accrue to the plant operator. The amount ascribable to vapor recovery has not been determined.

Secondary systems (processing of hydrocarbon vapors) can control both working and breathing losses. However, they are seldom used in bulk plants; only one operating unit was located in this survey. If such systems were installed in conjunction with balance systems they would add an estimated $6,000 to the initial costs. Operating costs appear to be significant but are difficult to define. Safety seems to be a strong consideration in the selection of a secondary system. No single type of secondary system was clearly superior to the others. The sole operating secondary system found during the survey seems to provide acceptable control of breathing losses.

Breathing losses can be reduced by increasing the pressure settings of pressure-vacuum valves. However, in many cases acceptable control of such losses (90 percent or more) would require other measures primarily beacuse of the limited design capability, age and condition of typical tanks.

A model for estimating vapor control efficiency of a balance system is formulated. Ideal expansion of a perfect gas is used to calculate final vapor conditions. Actual heat transfer, mass transfer, friction losses, leakage, and thermal expansion are evaluated and treated as increments to the ideal case. Test results, contractor data and model evaluation indicate that the most significant factor in the efficiency of a balance system is vapor leakage. Leakage is apparently not primarily due to a poor seal at the transfer interface, as in the case of vehicle refueling, but inadequate design or maintenance of tank hatches, pressure relief valves, manhole covers, and pressure-vacuum valves.

Primary conclusions of the study are: (1) 90 percent reduction of working loss is possible with a balance system, but system requires leak-tight tanks and couplings; (2) present EPA regulations do not require control of significant bulk plant emissions from breathing and fugitive losses; and (3) cost for acceptable control of all hydrocarbon emissions (including breathing losses) by the most common control technique, which includes conversion from a top-loading system to a bottom-loading system, may be beyond the financial capability of the average independent small bulk plant owner; however, less expensive control techniques may be available.

3. TYPICAL BULK PLANT AND INVENTORY

3.1 INVENTORY

This section provides the data base (inventory) which is used to classify and measure the applicability of vapor recovery systems to bulk plants.

A comprehensive inventory of bulk plants in the San Diego (California), San Joaquin Valley (California) and Denver (Colorado) AQCR's was compiled. Data were derived from EPA, Colorado Air Pollution Control Division, Colorado Department of Health, California Air Resources Board, local county air pollution control offices, California Oil Marketers Association, Colorado Petroleum Marketers Association, major oil companies, local telephone directories and field surveys. Due to the quantity of information desired, only a sample of respondents were queried on each detailed question.

A large amount of specific information for each plant was sought in addition to identification of the numbers and location of affected bulk plants. The specific data obtained, including sources of information, are documented in Appendix A. Appendix C lists the additional sources of information.

Information presented in the inventory (Appendix A) deals with identification and location of each plant, size of the operation (in terms of throughput of gasoline), its storage capacity and storage facilities, the number and types of trucks used, the status of each plant with respect to control of vapor loss (in terms of submerged filling and vapor recovery systems) and the current distribution of customer accounts.

Detailed information not presented in the inventory was also requested for a small sample of respondents. Small sample size was typically in the order of 20. This information included items such as hours of operation, other business conducted at the plant, size of individual accounts, details of the operations, facilities and site layouts, and cost data regarding vapor control installations. The latter information is tabulated and discussed in Section 6.

The inventory covered 17 counties, twelve of them in California and five in Colorado.* Each county had at least one operating bulk plant dealing in gasoline; the largest number of such plants was 47, in Fresno County, California. In all, 306 bulk plants were surveyed and 263 were found to be currently engaging in receipt and delivery of gasoline. Of these, 208 were in San Joaquin Valley, 10 in San Diego County, and 45 in the Denver AQCR. Of the 263 plants assumed to be operating at the time of the survey, one plant was in the process of closing and 15 stated that they may close or are planning to close their bulk plants. This information was volunteered by the operators of the plants. No correlatable reasons for the closures were obtained; therefore, inputs obtained are not definitive and cannot be used to determine rates of closure.

Of those who responded to specific questions, the inventory indicates 53 percent were equipped with vapor balance systems to prevent losses on transfer of incoming loads, whereas only 9 percent were equipped to prevent such losses for outgoing loads. Submerged filling, a system for reducing vapor losses on outgoing loads, was in use at 74 percent of the plants which answered the question concerning submerged filling.

The degree of implementation of these control measures was not uniform among the three AQCR's investigated. The prevalence of vapor balance systems for incoming loads was 80 percent in San Diego County, 56 percent in the San Joaquin Valley, and 18 percent in the Denver Metropolitan AQCR. The prevalence of vapor balance systems for outgoing loads at plants which information was obtained was 60 percent in San Diego County, 5 percent in the San Joaquin Valley, and 7 percent in the Colorado counties. Submerged filling was practiced at most of the plants where neither vapor recovery systems nor bottom-loading were in use, and for which the information was provided. This was the case for 81 of 111 such plants (73 percent) in the San Joaquin

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* The Metropolitan Denver Air Quality Control Region comprises Denver City and County and seven surrounding counties. In three of these counties, namely Clear Creek, Douglas and Gilpin, no bulk plants were located.

Valley AQCR; 9 of 10 (90 percent) in the San Diego County AQCR; and 6 of 7 (86 percent) in the Denver Metropolitan AQCR. These differences may be caused, in part, by differences in the regulations which are in effect in the various AQCR's and counties.

Figure 3-1 shows the distribution of operating small bulk plants classified according to daily gasoline throughput. Although the arbitrary upper limit for bulk plants is 76,000 liters (20,000 gallons) per day, 99 percent of the plants surveyed delivered 76,000 liters (20,000 gallons) per day or less and about 90 percent of the plants surveyed delivered 38,000 liters (10,000 gallons) or less each day. The average throughput was about 20,000 liters (5,000 gallons) per day. Slightly over 50 percent of the plants had daily gasoline throughputs of 15,000 liters (4,000 gallons) or less with the median also at a throughput of 15,000 liters per day. This value was thus taken as the throughput of a typical small bulk plant for this study. The total daily throughput of these plants is estimated to be in the order of 5 million liters.

About 60 percent of the gasoline delivered by these plants is reported to go to small agricultural accounts, i.e., agricultural customers having storage capacities of 2,100 liters (550 gallons) or less. The small agricultural users are exempt from EPA requirements regarding vapor recovery systems. Another 20 percent is delivered to gasoline service stations; the remainder, 20 percent, goes to larger agricultural accounts and to commercial users. For purposes of this inventory, it was not feasible to determine what fraction of bulk plant gasoline throughput was normally delivered to service stations in the exempt category.

Table 3.1 presents a summary of these inventory data, together with some of the more important details of storage and delivery capacities and vapor loss control provisions.

Further analysis of the data indicates the following: (1) approximately 2/3 of plants had above-ground storage, 1/4 had underground

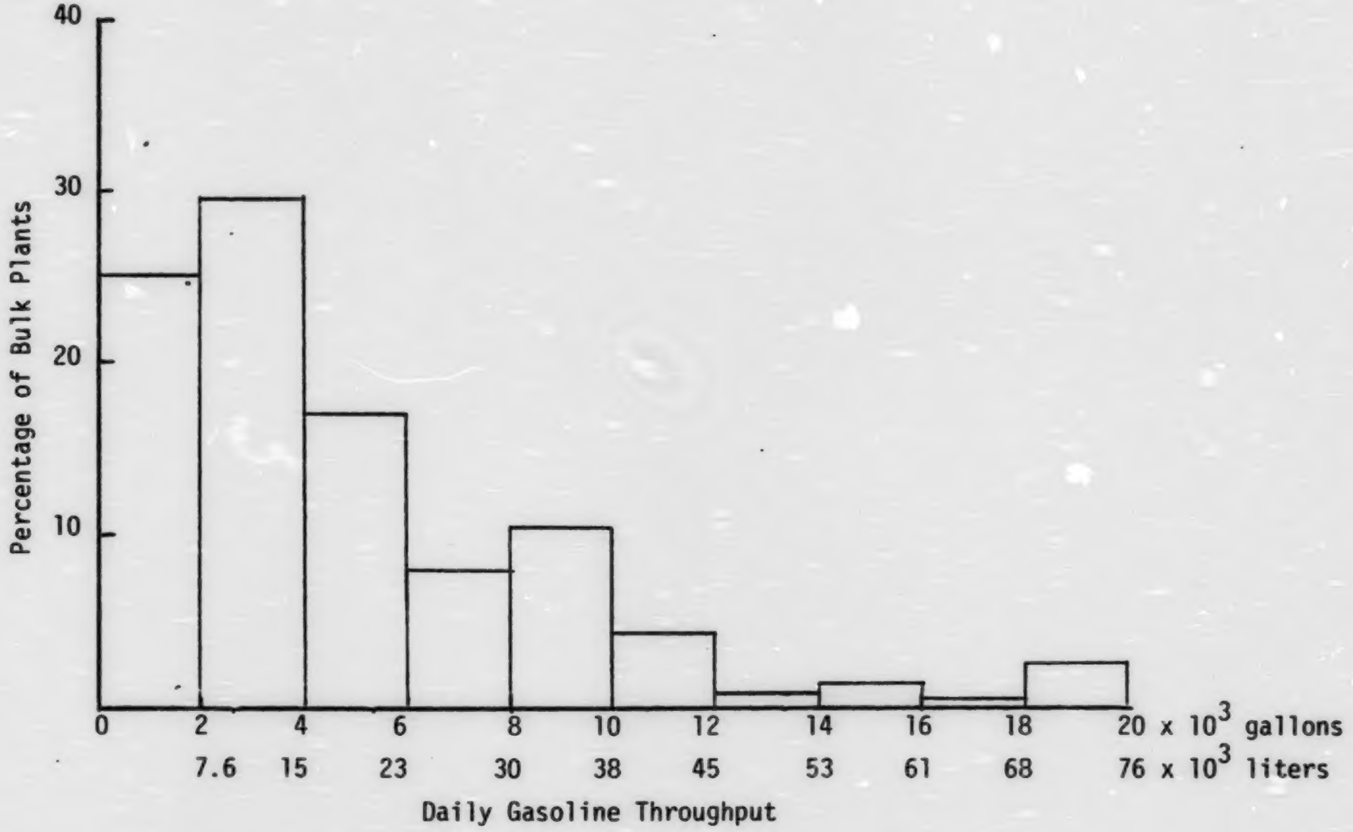


Figure 3-1. DAILY GASOLINE THROUGHPUT HISTOGRAM

Table 3-1

SMALL GASOLINE BULK PLANT INVENTORY, SUMMARY

County	No.[a] of Bulk Plants	Gasoline Throughput Liters/day[b]	GASOLINE STORAGE TANKS[c]				% of with Vapor Recovery on Incoming Loads	OUTGOING LOADS					CUSTOMER ACCOUNTS[h]	
			Avg. No. of Tanks	% of Plants with Above-Ground Tanks Only	% of Plants with Under Ground Tanks Only	Avg. Storage Capacity Liters[b] $x10^{-3}$		% of Top Loading	% of Bottom Loading	Avg. No. of Trucks	% of Plants with Submerged Fill	% of Plants with Vapor Recovery	Avg. % Small Agricultural	Avg. % Service Stations
California														
Amador	1	16,600	3.0	100	0	101	0	100	0	N.D.	100	0	60	40
Calaveras	4	20,900	3.0	67	33	113	0	100	0	3.0	N.D.[d]	0	53	33
Fresno	47	26,800	3.6	66	21	227	42	89	11	2.4	70	5	67	27
Kern	35	13,100	2.6	77	23	144	91	100	0	2.1	90	0	49	N.D.
Kings	10	11,100	3.2	80	20	165	N.D.	100	0	2.2	100[e]	0	73	13
Madera	11	20,600	2.6	73	27	163	0	100	0	1.7	88	0	69	31
Mariposa	3	12,700	3.0	33	67	156	33	100	0	2.0	50	0	75	13
Merced	18	23,800	3.1	71	29	196	78	89	11	2.1	25	11	74	17
San Joaquin	21	11,700	2.9	67	22	177	29	75	25	2.0	78	0	13	44
Stanislaus	24	34,400	3.9	73	9	204	100[f]	N.D.	N.D.	2.0[e]	N.D.	N.D.	63	16
Tulare	31	25,500	3.2	52	45	178	72	97	3	2.2	79	7	73	15
Tuolumne	3	14,500	3.3	100	0	214	50	100	0	2.0	100	0	30	52
San Diego	10	17,400	2.4	40	60	115	80	40	60	2.2	90	60	57	43
Colorado														
Adams	7	19,700	2.6	86	14	117	20	100	0	1.7	N.D.	0	78	1
Arapahoe	4	38,000	5.3	67	33	179	0	100	0	2.0	100	0	18	57
Boulder	19	13,800	3.8	94	6	142	14	93	7	1.4	75	20[g]	60	39
Denver	13	23,600	2.9	50	50	146	22	90	10	2.1	100[e]	0	1	18
Jefferson	2	8,900	4.0	100	0	155	0	50	50	1.5	N.D.	0	15	50
Totals														
California	218	21,400	3.2	66	28	183	58	90	11	2.2	74	9	64	23
Colorado	45	19,200	3.5	79	21	142	18	92	8	1.7	86	7	44	31
Survey	263	21,100	3.2	68	27	177	53	90	10	2.1	74	9	61	25
Number of Respondents	- -	237	204			242	179	187		205	128	155	197	141

NOTES:
a - Plants stated to be operating at time of survey
b - Divide by 3.785 to obtain gallons
c - Where totals do not equal 100, indicates plants with both above- and underground tanks
d - N.D. = no data
e - Only one response
f - Only three responses
g - Only four responses
h - Where totals do not equal 100, indicates other types of accounts served (commercial, large agriculture, etc.)

storage and the remainder had both; (2) number of tank trucks owned by operator averaged 2 for customer delivery and nearly zero for incoming trucks, (3) average pump flowrate for above ground tanks was 490 liters (130 gallons) per minute for both incoming and outgoing deliveries; (4) distance from load rack to above ground storage tanks, as well as from incoming truck transfer point to storage tanks averaged approximately 15 meters (50 feet); (5) average distance from underground tank to load rack was approximately 9 meters (30 feet); (6) bottom loading capability was present in only 10% of bulk plants (8% if San Diego data is excluded) with a distribution, excluding San Diego County, shown in Figure 3-2; (7) average number of gasoline storage tanks was 3, but several other similar tanks were typically present storing other petroleum products; (8) total gasoline storage capacity was approximately 180,000 liters (50,000 gallons) but could be increased (or decreased) if required by dedicating (or removing) a storage tank from gasoline service; (9) approximately 1/3 of the plants were operated by comission agents while the majority of independent owners operated single bulk plants; (10) the typical limit of pressure differential for above-ground storage tanks was not more than 3,450 Newtons/m^2 (0.5 pounds per square inch) gauge for internal pressure, and about 510 Newtons/m^2 (0.06 pounds per square inch) for vacuum; (11) typical incoming gasoline load of approximately 34,000 liters (9,000 gallons) was delivered by a tank truck and trailer owned by a major oil company or commercial carrier; (12) transfer line sizes ranged from 5 to 10 cm (2-4 inches) in nominal diameter; (13) paint on above-ground tanks was predominantly either white or metallic (silver); and (14) number of compartments on each account truck averaged 4, ranging from 2 to 6. Implications of these data are discussed in other sections of this report.

3.2 TYPICAL BULK PLANT

This section describes the typical bulk plant encountered in the survey of small bulk plants in the ACQR's studied. Among subjects discussed are facilities, customers, regulations and operations.

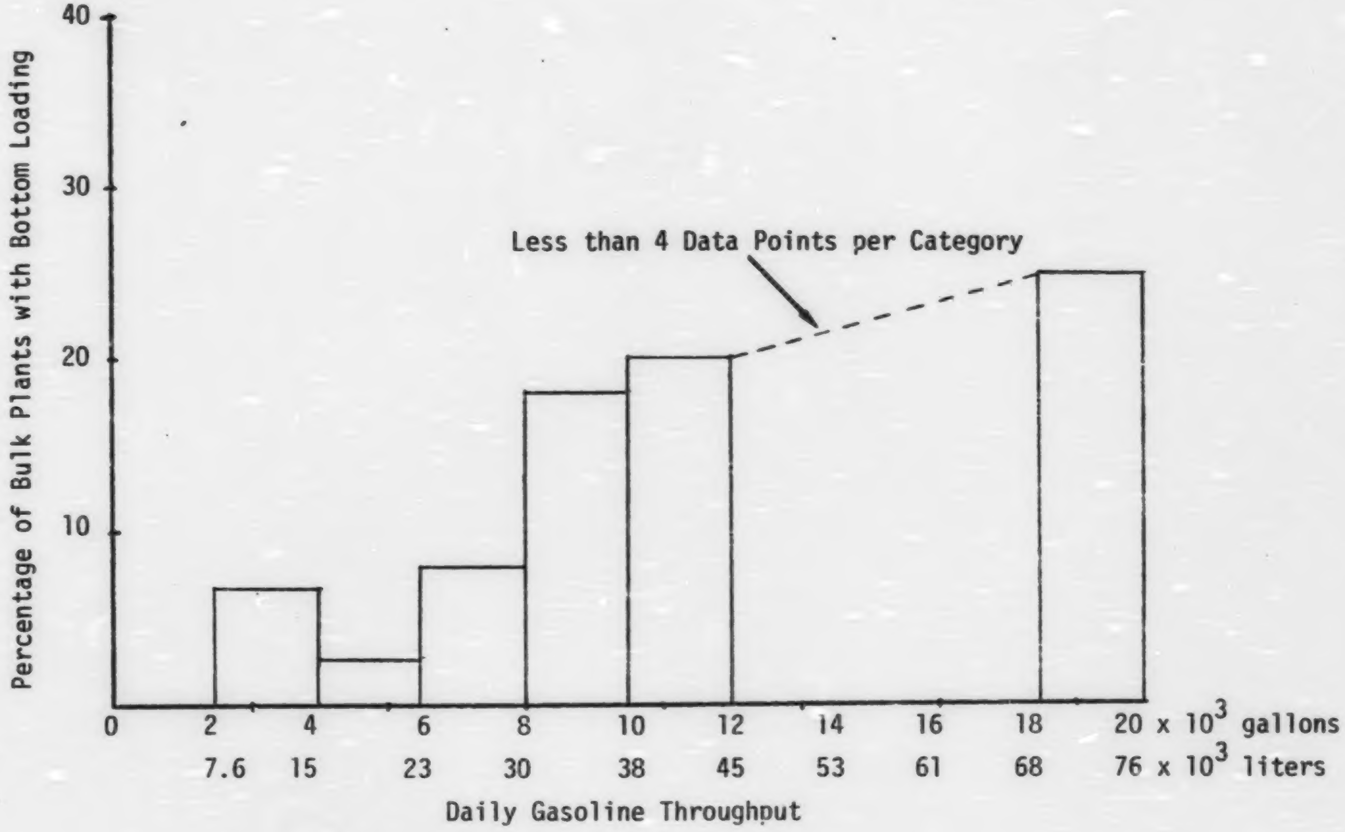


Figure 3-2. BOTTOM LOADING VERSUS THROUGHPUT (EXCLUDING SAN DIEGO COUNTY)

3.2.1 Bulk Plant Facilities

The description of bulk plant facilities is divided into four categories: (1) type and size of tanks for gasoline storage; (2) type of loading rack; (3) type, size and number of incoming trucks and (4) type, size and number of account trucks. Figures 3-3 and 3-4 give schematics of typical bulk plants.

3.2.1.1 Gasoline Storage

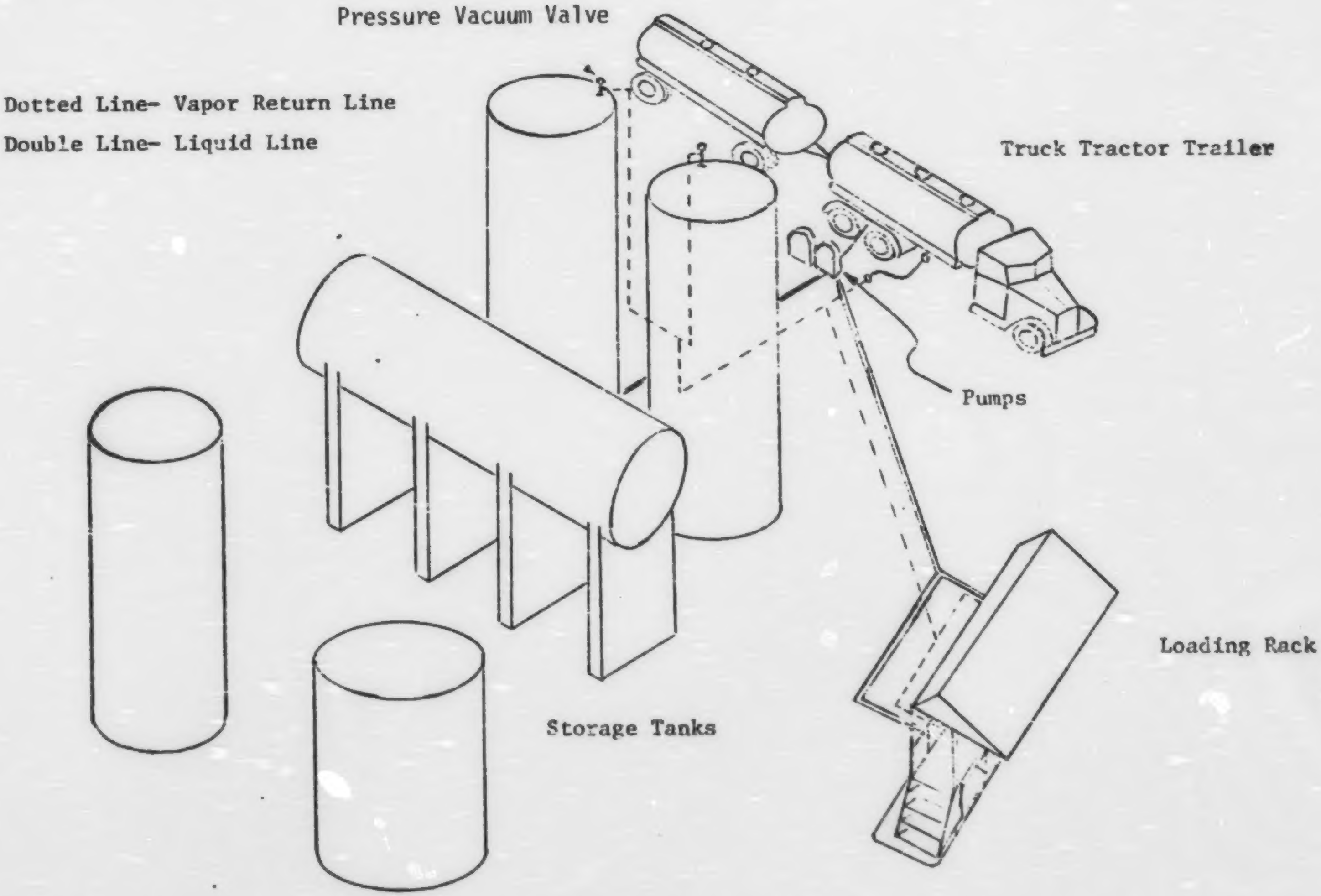
Gasoline storage tanks are either above or below ground. Above-ground storage facilities account for approximately 2/3 of all the bulk plants, underground for about 1/4 of all bulk plants with the remainder having facilities of both types. Floating roof tanks were never encountered in this survey.

Above-ground tanks are cylindrical with domed ends and axis either vertical or horizontal. Typical capacities ranged from 49,000 to 76,000 liters (13,000 to 20,000 gallons). The number of gasoline tanks, per plant, varied between 1 and 8 with an average of three, resulting in a storage capacity of approximately 180,000 liters (50,000 gallons). The range was from 25,000 to 570,000 liters (6,700 to 150,000 gallons). Above-ground tanks are typically painted either white or metallic (silver) to reduce heat absorbance and are normally 3 meters in diameter and 6 to 9 meters high (10 1/2 feet diameter and 20 to 30 feet high). Similar tanks are also used to store other petroleum products, including diesel fuel, kerosene, weed oil, lubricants, and fuel oils.

Underground storage tanks tend to be more prevalent in the larger cities, and are typically of 38,000 liter (10,000 gallon) capacity. Three gasoline tanks are an average number per plant.

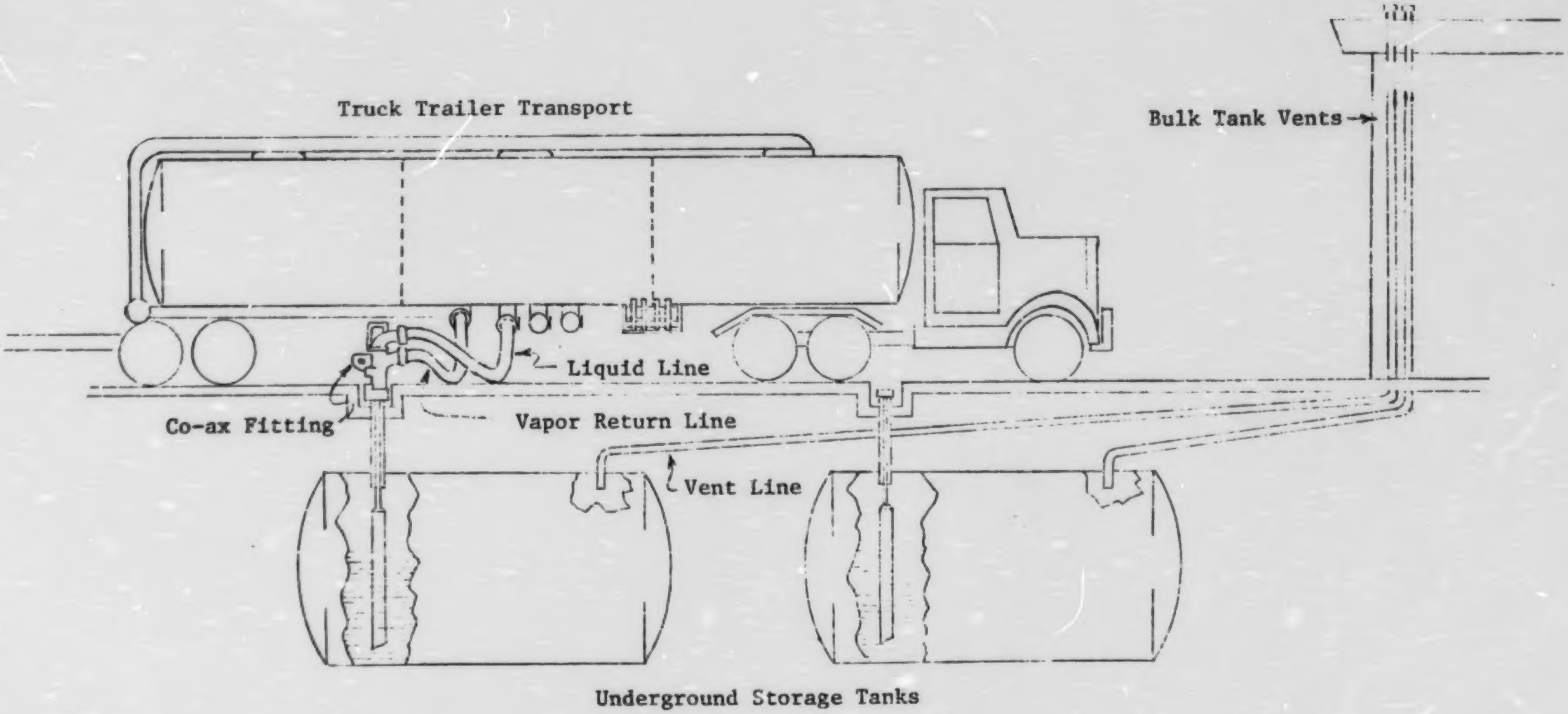
3.2.1.2 Loading Racks

Two types of loading racks are used, top-loading (or overhead loading) and bottom-loading. Approximately 90% of surveyed plants used top-loading. The top-loading process consists of using a loading


Pressure Vacuum Valve
Dotted Line- Vapor Return Line
Double Line- Liquid Line
Truck Tractor Trailer
Pumps
Loading Rack
Storage Tanks

(Not all of the Vapor Return Line and Liquid Line are shown)
(Catwalk for Storage Tanks not shown)

Figure 3-3. SCHEMATIC OF TOP LOADING BULK PLANT EQUIPPED WITH VAPOR RECOVERY


Truck Trailer Transport
Bulk Tank Vents
Liquid Line
Co-ax Fitting
Vapor Return Line
Vent Line
Underground Storage Tanks

(Trailer not shown)

Figure 3-4. TYPICAL BULK PLANT WITH UNDERGROUND STORAGE EQUIPPED WITH VAPOR RECOVERY FOR TRANSPORT DELIVERY

arm or delivery tube normally mounted on some type of swivel joint that can be extended over the top hatches of the tank truck.

Top-loading arms are part of the loading rack (Figures 3-5, 3-6). A typical loading rack includes shut off valves, meters, relief valves, electrical grounding, lighting, and bypass plumbing. Supply of loading rack is from underground piping. Trucks are loaded by either splash filling or submerged filling. Splash filling keeps the outlet of the loading arm above the level of the liquid, usually just inside the compartment. Submerged filling extends the outlet to within 6 inches of the bottom, where it remains below the liquid surface throughout most of the loading process, by using either tubing or fixed outlets. Of all the top-loading plants surveyed, approximately 75% use submerged fill and this number is expected to increase since both California and Colorado state regulations now require this type of filling.

A bottom-loading rack is a ground-level facility, as opposed to the elevated platform used for top-loading. Here, the truck is filled through fittings at the side (Figure 3-7). An industry trend toward bottom-loading seems to be confirmed by our observations, independent of vapor recovery. Reasons given for this modification include: potentially larger costs for top-loading vapor-recovery systems; lack of compressed air (normally required for top-loading vapor-recovery equipment); faster loading; industry trends; safety; integration with customer vapor recovery requirements; improved vapor recovery efficiency; and loading versatility. Approximately 10% of the bulk plants surveyed have bottom loading. Most of these plants with bottom loading were owned either by major oil companies or by large multi-plant jobbers.

3.2.1.3 Truck-Trailer Transport

Approximately 10% of operators indicated they owned the incoming vehicle. Most commonly, vehicles owned by oil companies and com-

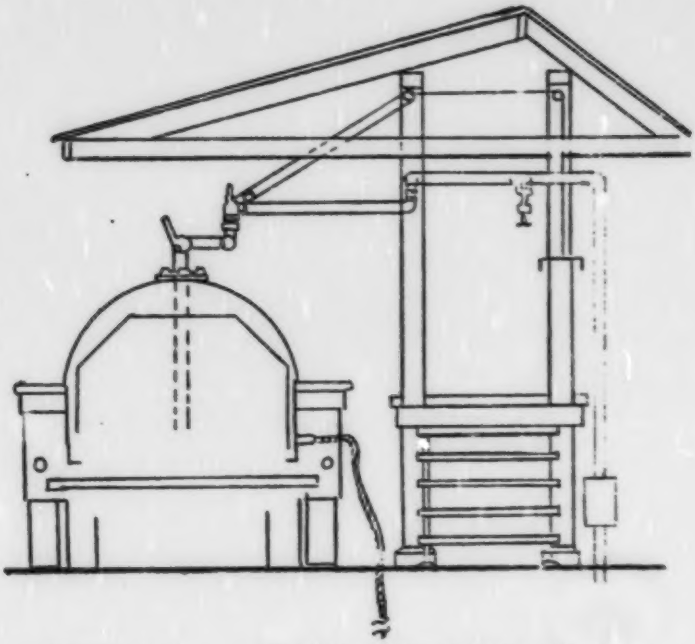


Figure 3-5. A TYPICAL TOP LOADING RACK

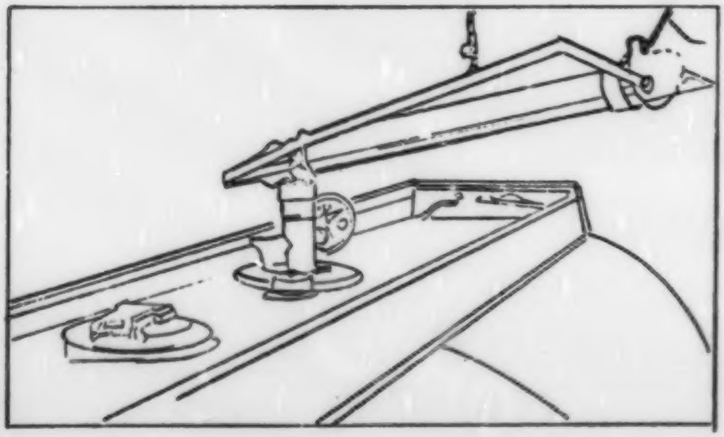


Figure 3-6. VIEW OF TOP-LOADING OPERATION

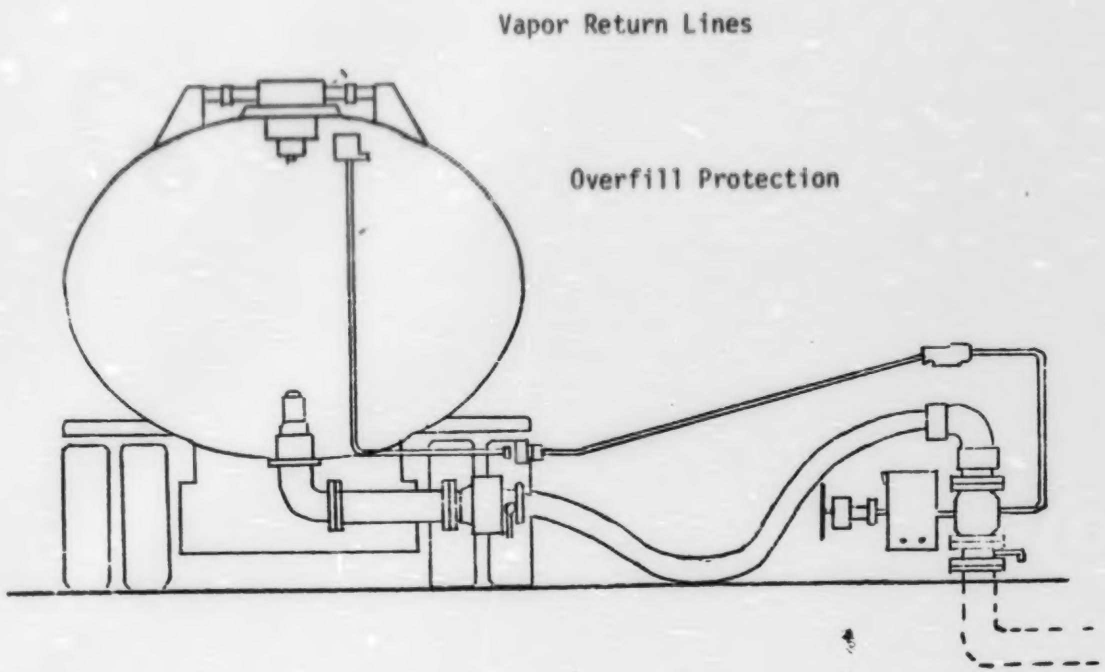

Vapor Return Lines
Overfill Protection

Figure 3-7. BOTTOM LOADING

mercial carriers were employed; such vehicles were not devoted solely to bulk plant service. These truck-trailer transports typically have four to six compartments and deliver approximately 34,000 liters (9,000 gallons) of one grade of gasoline to the bulk plant. One commercial carrier indicated a trend to fewer compartments because of limited use.

3.2.1.4 Account Trucks

Bulk plants average two account trucks each (commonly referred to as "bobtails"). These trucks may have a small cargo area at the rear for miscellaneous deliveries (i.e., drums). Typical capacities range from 3,800 to 7,600 liters (1,000 to 2,000 gallons), averaging 7,200 liters (1,900 gallons), with extremes of 1,900 and 23,000 liters (500 and 6,000 gallons). Account trucks average 4 compartments with a range of 2 to 6. These trucks may be loaded several times a day. Contents, as well as the number of compartments filled, vary with demand. Not all the compartments will always contain gasoline; at least one compartment will typically be loaded with another petroleum product, such as diesel fuel.

Account trucks are almost always owned by the plant operator, even when the plant is owned by an oil company. Observed operations in filling an account truck took from three to twenty minutes, averaging around twelve minutes. This is a function of how large the order is, how many compartments can be filled simultaneously, and filling rate. Account truck deliveries are not responsible for the entire throughput of a plant, as some accounts may bring their small tanks or drums to the plant for refilling.

3.2.1.5 Plot Layout and Other Facilities

Bulk plant facilities commonly include an area for warehouse and office use. Warehouses are used to store other petroleum products, sold in drums and cases, and accessories. The warehouse is normally furnished with a loading dock to facilitate the transfer of products. Utilities are typically restricted to electricity and water. The warehouse sometimes serves also as a garage for truck servicing, although a separate structure may be provided. Office space is generally limited to one room.

The average plot size of a bulk plant is approximately 3,400 square meters (37,000 square feet). Sizes ranged from 1,390 to 8,130 square meters (15,000 to 87,500 square feet). The plot is usually fenced. A layout of a typical bulk plant, shown in Figure 3-3, allows several operations to occur simultaneously. Storage tanks are normally grouped together with pumps. Pumps are sometimes protected against the environment by a separate building or shed (commonly referred to as a pump house). Bulk plants with underground tank storage need less space and plot sizes may be smaller.

Most facilities are rather old; the average age was approximately 36 years with a range from a plant built in 1912 to an in-progress complete refurbishment. Older plants are located on railroad sidings, since railroad was the common means of transporting products to the bulk plant. No deliveries by rail were noted during the survey. Rail facilities appear to be in complete disuse.

3.2.2 Typical Bulk Plant Accounts

Survey data indicated that on the average, approximately 60% of the bulk plant throughput was to small agricultural accounts. Figure 3-8 presents percent of gasoline throughput reported by operators to be delivered into small agricultural tanks of 2,080 liters (550 gallons) capacity or less. Splitting the bulk plants into two groups at 38,000 liters (10,000 gallons) per day or less versus plants with more gasoline throughput, a statistical test of difference between the means showed a difference at a level of significance of 0.10. This statistical result is consistent with the observation that larger plants with large throughputs tend to be located in large communities where there are relatively more non-agricultural customers.

Service station business (overall average of 20%) was strongly dependent upon location. In thinly populated areas with scattered small

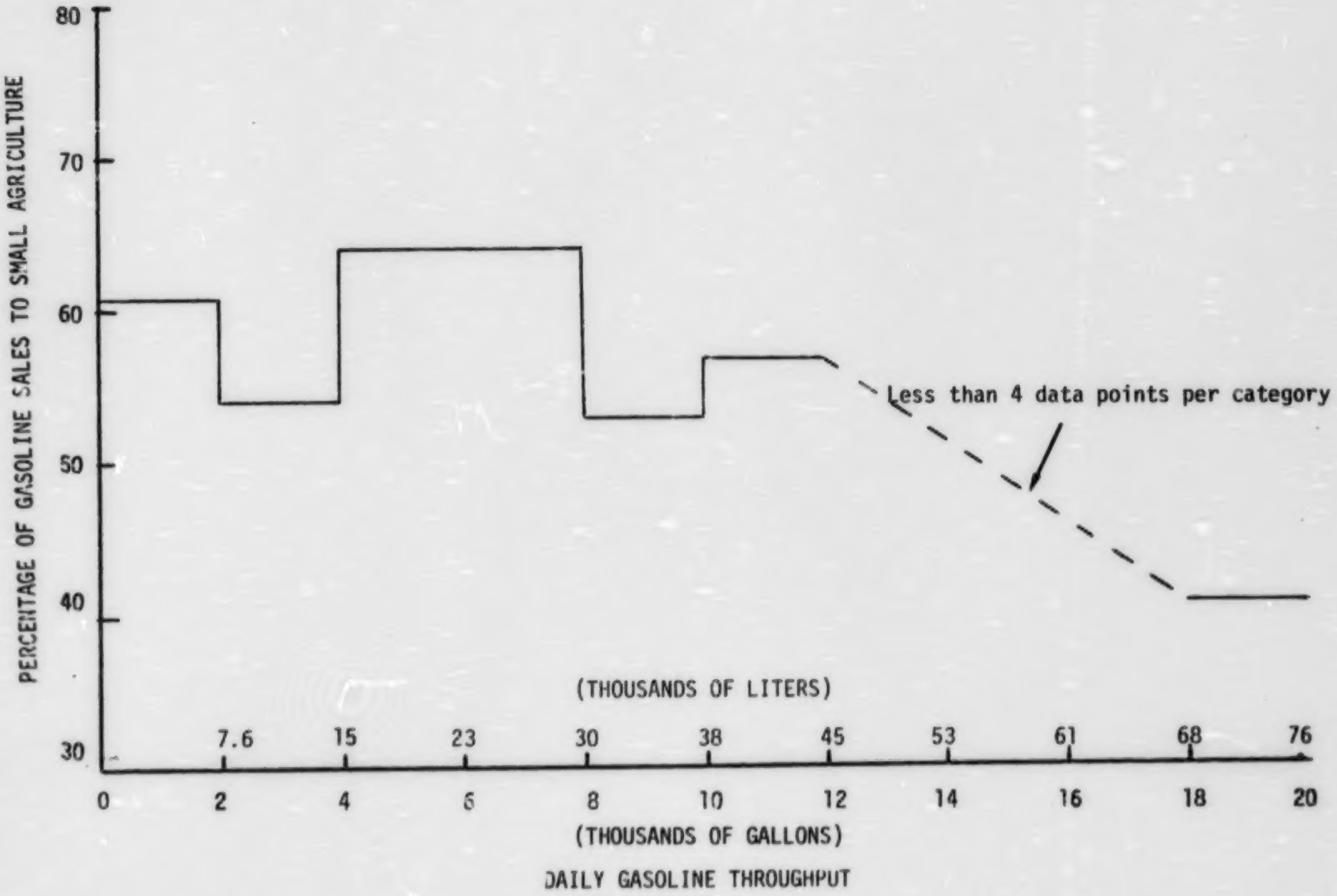


Figure 3-8. SMALL AGRICULTURAL SALES VERSUS THROUGHPUT

service stations or with regulations limiting truck or tank sizes (Boulder, Colorado, for example), bulk plant deliveries to service stations were higher than average. Thus, in mountainous Tuolumne County, California, with three bulk plants, average service station percentage was 50%. However, small agricultural accounts consistently receive a significant portion of gasoline throughput even in these areas. Exceptions occur when the plant is located in the heart of a major metropolitan area. Thus, although agricultural accounts averaged approximately 44% for the Denver AQCR, commercial accounts predominated in the city of Denver with agricultural accounts nearly non-existent.

3.2.3 Regulations

The EPA has promulgated gasoline transfer vapor control regulations for 13 AQCR's, including San Joaquin Valley (California) and Denver (Colorado). In other areas, such as San Diego (California), EPA did not promulgate regulations because existing local regulations were acceptable. EPA regulations essentially require use of a system capable of preventing the release of 90% of organic compounds displaced during the transfer of gasoline from any truck transport (delivery vessel) into any storage tank (stationary storage container). A summary of the regulations affecting the gasoline handling at bulk plants is given in Appendix E.

The effect of these EPA regulations varies. Where local regulations require it, a majority of bulk plants are planning to install or have installed vapor recovery equipment (balance systems) for incoming transfers. The few larger throughput bulk plants are generally planning to install or have installed vapor recovery systems (balance system in conjunction with bottom-loading) to outgoing transfers as well. San Diego, California regulations required all bulk plants to install vapor recovery systems (secondary system in conjunction with a balance system and bottom-loading) and most of those bulk plants remaining (nearly one half are no longer in business) are planning to install or have installed vapor recovery systems. Where local regulations do not require vapor recovery, bulk plants generally do not plan and have not installed vapor recovery (or bottom-loading).

3.2.4 Bulk Plant Operations

A typical bulk plant has three or four employees: operator; one or two drivers; and a clerk. The business may be a family operation.

On a typical day, operations at the plant will start at about 7:00 a.m. and end at about 4:00 p.m. Plant will operate five days each week. A driver opens the plant, with the operator arriving later. One of the first duties after a night delivery is to measure tank levels and temperatures. This is done to ascertain the quantity of gasoline delivered. This requires climbing to the top of the tanks, opening hatches, dropping plumb-bob tape or stick and recording the values. The thermometer is on a rope or chair (normally cotton or grounded chain to avoid static charge buildups and release) and is just dropped through the hatch to obtain the temperature.

After this has been done, the account trucks are loaded for deliveries. The account trucks are driven to the rack and hooked up, and the pump loop set for delivery. If the flow is impeded, the line upstream of the pump may be vented until liquid gasoline appears at the vent this process is commonly referred to as priming the pump).

If unleaded gas is to be loaded into a truck compartment previously filled with leaded gasoline the compartment must be completely emptied to avoid contamination with lead. Normally the residual gasoline in the compartment is drained into flameproof containers. Spillage usually results. An amount of diesel fuel is loaded into the compartment to flush the remainder of the leaded fuel. To accomplish normal filling of an account truck, the driver climbs the loading rack platform, crosses to the tank truck, grounds the truck and opens one or more hatches. He then swings the loading arm into the open hatch, turns on the pump and opens the fill valve. In newer facilities the driver also presets the amount to be loaded. Common practice is to visually observe the filling and manually shut off delivery. The driver may service the truck, checking lubricant levels, water, and fuel to insure proper operation, and load miscellaneous products to be delivered. The trucks are sometimes rinsed or washed and windows and mirrors are cleaned. Loading and servicing are usually accomplished within an hour.

Observed travel and delivery times range from half an hour to four hours, depending on trip lengths. Bulk plants that service mountain areas usually have the longest delivery times. While the trucks are on the road, other products are sold, such as lubricants, herbicides or other petroleum industry products. Some customers may arrive with drums or portable tanks to be filled at the plant. Batteries and other related products may be sold throughout the day also. Delivery business generally falls off through the day, and customer pick-up sales tend to increase.

If a truck-trailer transport delivery takes place, the driver of the transport may check storage tank levels to insure against overfilling and also to aid the bulk plant operator in scheduling the next load, but he generally works independent of the operator. Deliveries may occur after normal working hours as well as during the normal working day. Ordinarily, a single pump serves for both loading and unloading each storage tank, but separate pumps are provided for different tanks, especially where different grades of gasoline are stored. Directional flow changes are usually accomplished by a plumbing loop and several shut-off valves. The rate at which gasoline is pumped averages 490 liters (130 gallons) per minute with a range of 110 to 1,300 liters (30 to 350 gallons) per minute through a total average length of 30 meters (100 feet) of 5 to 8 cm (2 to 3 inch) diameter pipe. In some cases, multiple compartments are emptied at the same time; this usually happens when a delivery consists of a split load, i.e., different grades of gasoline in different compartmens.

Incoming delivery of gasoline is accomplished in approximately one hour. In most bulk plants, a separate area is set up for transport deliveries so as to allow deliveries of petroleum products to and from the plant to occur simultaneously.

Incoming deliveries to a facility with underground storage are similar, except that the product is usually dumped (gravity load) rather than pumped into the tanks. This process is similar to incoming deliveries at a service station. The delivery times vary with equipment, line size, vent restriction, depth of tank and amount of transfer and residual in tank, however, transfer is generally faster than into an above-ground storage tank.

Normally the truck-trailer transport is not checked through the top hatches to insure that all the gasoline compartments are emptied; however, some operators do this as a standard practice. Since some loads arrive outside the plant's normal working hours, inspection by the operator may be intermittent.

Although general housekeeping may be performed throughout the entire day, rarely are tank hatches, vents, dry break connectors, hoses, or pumps serviced. Maintenance is normally performed only after breakdown occurs. This conclusion of general lack of periodic maintenance is based upon operator responses and visual observation of rusted or painted-over access ports. Keeping stock on supplies is either up to the operator's initiative or is set by the oil company as required over specified time periods.

In summary, activities other than the transfer of gasoline may lead to increased hydrocarbon emissions at bulk plants. These include: (1) periodic measurements of liquid level and temperature by inserting instruments through the tank hatch, since the system is sometimes at a positive gauge pressure and some vapor-laden air escapes, (2) when pumps are primed, vapor-laden air is eliminated from the liquid lines by venting, and (3) maintenance, cleaning and flushing, operations may require venting or opening of hatches and valves with loss of vapor and occasionally, liquid gasoline.

3.2.5 Industry Overview

Bulk plants at one time constituted a major link in the wholesale distribution of gasoline and petroleum products (References 3-a and 3-b). Forty years ago, bulk plants received gasoline by rail tank cars shipped from relatively few refineries or terminals. For example, an operator in San Diego County at one time received gasoline by rail from San Francisco. From the bulk plant, most of the gasoline went to retailers (service stations).

Today, the rail delivery of gasoline has nearly disappeared even though many bulk plants are still located near railroads. A typical delivery of gasoline to the bulk plant is by truck-trailer transport. This shift in transport has allowed larger accounts not located near the railroad to receive deliveries direct from a pipeline terminal or a refinery. This is especially true for gasoline retailers (service stations).

Thus, today the bulk plant is primarily a specialty petroleum products retailer providing bulk delivery service to those small accounts that (1) find it inconvenient to bring small tanks to a large outlet, (2) have fixed storage tanks of low capacity, or (3) desire quick delivery due to highly variable demand. In addition, bulk plants provide rapid delivery to customers who bring tanks to be filled.

Figure 3-9 presents a diagram of that portion of the gasoline distribution network most directly related to bulk plants. The major competition for bulk plants is direct bulk sales from the refinery or terminal. Some advantages of bulk plant over direct bulk sales are (1) closer proximity to customer, (2) faster response to variable customer demand, (3) use of smaller trucks for better access to off-road customer locations, and (4) ability to store and supply other products required by customer. Some disadvantages of a bulk plant compared to direct sales are (1) higher capital costs, (2) increased labor involved in transfer, storage and filling of smaller trucks, and (3) smaller truck size which is less appropriate to higher demand accounts.

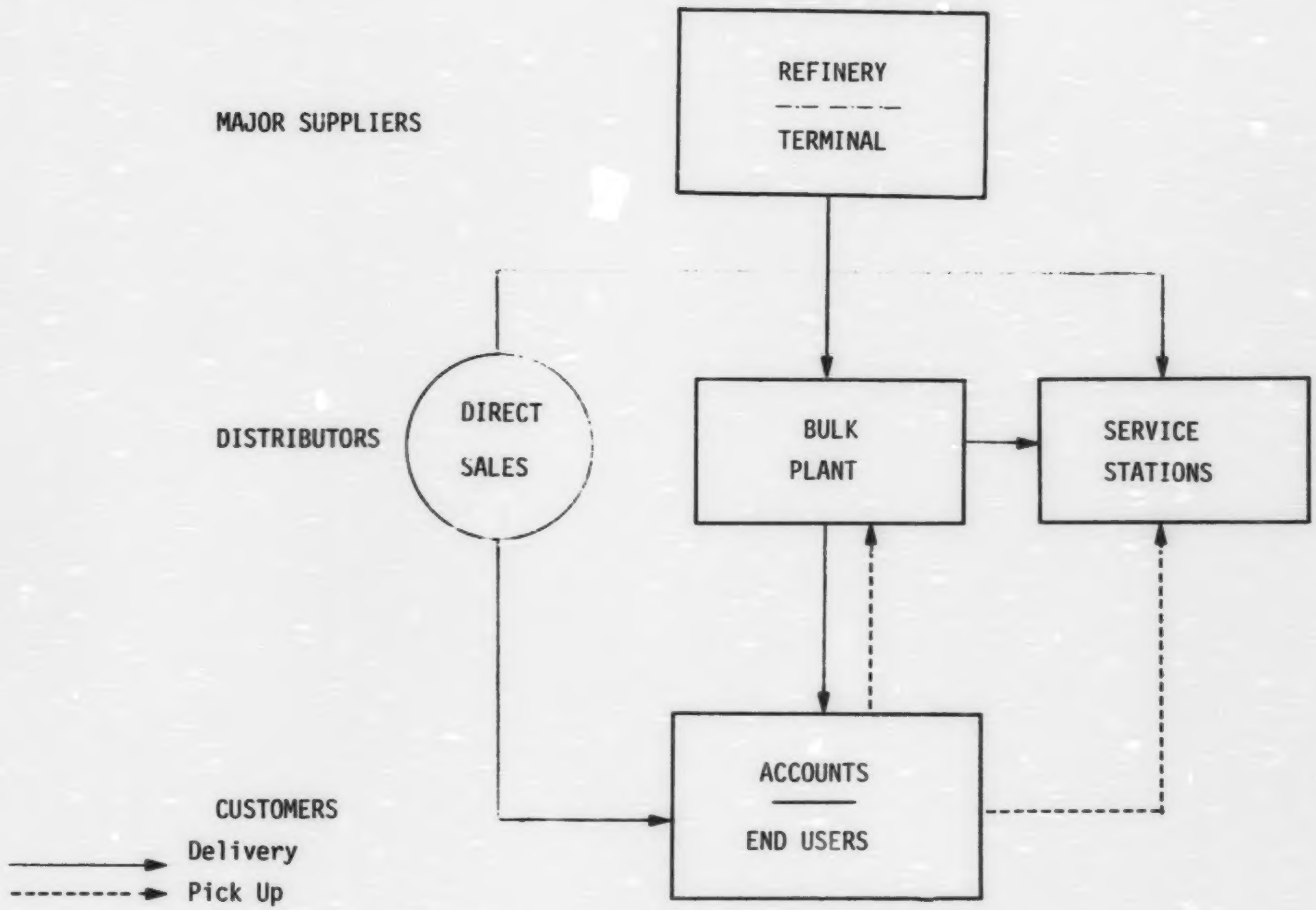

MAJOR SUPPLIERS
DISTRIBUTORS
CUSTOMERS
REFINERY
TERMINAL
DIRECT SALES
BULK PLANT
SERVICE STATIONS
ACCOUNTS
END USERS
Delivery
Pick Up

Figure 3-9. APPLICABLE GASOLINE DISTRIBUTION NETWORK

A second source of competition for bulk plants is large retail outlets. Some advantages of a bulk plant over a retail outlet are (1) convenience or necessity of "home" delivery, (2) higher delivery flowrate capability for bulk deliveries, (3) a potential wholesale price, and (4) a potential lack of road taxes. Disadvantages of bulk plants over a larger retail outlet include: (1) higher capital costs, (2) increased labor costs for account service, and (3) inability to completely service user vehicles.

Although owners and operators of bulk plants include cooperatives and salaried employees, they are more typically independent jobbers and commission agents. The typical independent jobber owns the equipment and structures, the inventory and the rolling stock. He contracts directly with the oil company to secure his gasoline at the most advantageous price and then sells the gasoline to his customer at terms he and the customer negotiate. He may market a nationally known brand of gasoline and related products, but he may also market under his own brand. Some jobbers also own more than one plant and service station. A typical commission agent does not own the land, structures or equipment but operates the plant for a major integrated oil company. He owns his account trucks and may contract with customers, but he must operate within the framework of his contract with the major oil company which is supplying his products.

Gasoline bulk plants appear to be diminishing in importance in the marketing sector of the petroleum industry. This conclusion is based upon: (1) the nationwide decrease in number of operating bulk plants from a 1972 survey (Reference 3-c) to a 1975 survey (Reference 3-d), (2) major oil company sales or closing of bulk plants operated by commission agent (Reference 3-e), and (3) the number of bulk plants recently closed in the surveyed AQCR's. Reasons for this decline are varied, but all appear to be related to economic factors.

These economic factors appear to be a result of the extra cost to transfer gasoline from truck to a storage tank and then back to another truck. Cost of bulk-plant-related labor and capital are eliminated if the initial transport can deliver directly to an account. In addition, the number of traditional small-business customers may be declining. Small service stations are being replaced (or eliminated, per Reference 3-d) by larger outlets serviced from a terminal or refinery. Many agricultural accounts now primarily depend upon diesel fuel or electrically powered equipment. Reference 3-f indicates that a typical San Joaquin Valley farm is 1,500 acres. Large agricultural accounts may be able to obtain deliveries from a terminal or refinery.

There appears to be a decrease in profitability in bulk plants. This conclusion is based upon (1) statements by independent operators during survey, and (2) difficulty in selling bulk plants as a going business (Reference 3-g). The reasons for this decline are also varied, but may include: (1) a shift in profit emphasis by major oil companies from expanding sales volume to maximizing the profit per gallon; (2) an increase in wholesale prices, especially to independent jobbers (one independent operator claimed the wholesale price he paid for gasoline was within one cent per gallon of retail gasoline price in the area), and (3) competition from reduced-margin self-service stations.

Reference 3-e, as well as survey results, indicate a larger decline in major-oil-company-owned bulk plants than the overall decline. Typical disposal (Reference 3-g) involves offering the plant for sale to the commission agent. If the offer is declined, the plant is generally dismantled and the land is sold.

A small number of bulk plants surveyed were planning to install keylock systems, i.e., self-service loading racks or pumps which allow a customer with a key or card to actuate the delivery pump and obtain the product. This conversion to a specialty, self-service retail outlet, yields a very low cost-margin potential but such service may not be economical for customers who cannot pick up the product. The fate of keylock systems again appears to be related to economics, that is, whether the price difference will attract a sufficient number of customers to pick up the product.

Two other counter-trends, which may be temporary, are: (1) the desire to increase emergency fuel storage capabilities should an oil embargo or other shortage occur and (2) establishment of no-lead distribution. No-lead gasoline demand may be initially for small quantities. These small quantities plus the potential lack of separate pipelines may lead to its distribution through existing bulk plants. These conclusions are based on (1) survey results; (2) observed tank truck deliveries of no-lead to terminals, and: (3) salvaging, if possible, and moving of storage tanks from closed bulk plants (Reference 3-g). These counter trends, however, do not appear to strongly influence the fate of bulk plants.

Other factors influencing the fate of bulk plants include OSHA requirements. OSHA spill prevention requirements require proper drainage and diking of above-ground storage tanks. Associated requirements include explosion-proof pump motors, safe walking and working surface and additional safety equipment for personnel and facilities to comply with the Occupational Safety and Health Act (Reference 3-h).

Federal Energy Administration (FEA) regulations can also have a strong impact on the future of bulk plant operations. Title 10, Section 211.9 of the Code of Federal Regulations (1976 edition) requires that FEA must approve of any changes in gasoline supply to "all wholesale purchaser-resellers and all wholesale purchaser-consumers" except where there is mutual consent of the supplier and wholesale purchaser to terminate the relationship. Discussions with the FEA (Reference 3-i) indicated changes to individual wholesalers are generally approved as long as the total supply to a region is not significantly affected. These regulations are intended to promote the status quo relationship between the supplier and the wholesaler, but their effectiveness is unclear.

Miscellaneous difficulties noted by operators concerning facility, equipment and operations during the survey included: (1) fire code regulations, (2) theft, and (3) availability of insurance at reasonable rates. Positive factors noted by operators include: long established customer relationships, and an increase in demand for some petroleum products distributed. In addition, bulk plant operators are active politically (Reference 3-j). This activity is in parallel with the strong desire of small farmers to maintain low fuel costs.

In summary, many industry-wide factors beside vapor recovery regulations affect individual bulk plant operators. Negative factors include reduced profit margins, difficulties in supply, expenditures required by local and Federal regulations, costs of maintaining or replacing aging equipment, and loss of customers to direct terminal delivery and low margin service stations. Positive factors include: potential economies and appeal of keylock systems, strong customer relationships, and increasing demand for some petroleum products. A common complaint of many operators is that regulatory agencies consider only the isolated impact of their regulations whereas the operator views the regulations in a broader context. The operator must ascertain the total future demands on his (or her) resources rather than a single present demand such as vapor control regulations. If the operator concludes that future trends are unfavorable, he may not be willing to comply with even minimal regulations.

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4. HYDROCARBON EMISSION AT BULK PLANTS

This section estimates the amount of uncontrolled gasoline vapors which are emitted from a typical bulk plant. Each type of emission process is discussed. The importance of the parameters and applicability of published factors relating to the amount of vapors emitted are also reviewed. Applicable emission equations were converted to the International System of Units (SI). Typical bulk plant data were then used to estimate average emissions from gasoline storage and handling at these bulk plants. A brief review of emission factors from various sources is presented.

4.1 SOURCES OF EMISSIONS ASSOCIATED WITH HANDLING OF GASOLINE

Vapor can escape from storage tanks, even when there is no transfer activity, because of changes in temperature of the tank wall and stored materials which vary the pressure in the vapor space. Variation forces vapor-laden air out of the tank and aspirates fresh air into the vapor space, allowing further vaporization of gasoline into that space. The amounts of vapor escaping under these conditions are referred to as "breathing losses." Losses of vapors due to liquid transfer are referred to as "working losses" or "transfer losses." The liquid transfer forces air-hydrocarbon vapors out during filling of the tank and ingests air (promoting evaporation) during draining. Miscellaneous or fugative losses are primarily related to spillage and leakage during gasoline handling.

4.1.1 Breathing Losses

Originally, petroleum products were stored in open wooden tanks with roof (Reference 4-e). Primarily because of fire danger, atmospheric pressure steel tanks have replaced wooden tanks. Pressure-vacuum valves allow some pressurization, but old steel tanks are limited to low pressures.

Factors affecting breathing or standing losses for fixed roof tanks include the amount and volatility of the gasoline stored, type and condition of tanks and appendages, and the prevailing meteorological conditions. If there are no leaks or direct openings, temperature fluctuation is the major cause of breathing losses. As the temperature of the liquid rises, the vapor pressure increases and evaporation takes place. The overall pressure in the gas space increases and when the vent pressure set point is exceeded, a mixture of air and hydrocarbons is discharged into the air. As the temperature decreases, gases partially condense, contract, and fresh air is drawn into the vapor space. This permits additional hydrocarbons to vaporize. Since hydrocarbons are emitted, but generally not drawn back into the tanks, a continued loss of hydrocarbon results from the daily changes in ambient temperature.

4.1.2 Working Losses

The principal cause of vapor loss during liquid transfer is displacement of the gas (air laden with hydrocarbon vapors) in the vapor space by the liquid entering the tank. Other causes include the entrainment of liquid droplets in the displaced gas and post-withdrawal pressure increase caused by evaporation.

Certain operating conditions can increase or decrease these vapor losses. Splash loading in which gasoline is dumped onto the surface of the liquid causes turbulence which increases evaporation rates and entrainment of droplets in the vapor being displaced. A short interval between emptying and filling of storage tanks can decrease losses by minimizing the time allowed for evaporation. Also, storage tanks can be emptied in increments over a period of several days or can be emptied in one operation prior to refilling, with resultant differences in vapor loss.

Assuming no controls, each time a gasoline tank is filled, the vapors above the liquid surface are emitted to the atmosphere. The quantity of hydrocarbon vapors emitted is a function of the volume displaced, type of loading, temperature and the degree of saturation of the vapor space with gasoline vapors. At any given temperature, the amount of vapor in the vapor space cannot exceed a limit imposed by the saturation pressure corresponding to that temperature. This limit, however, increases as the temperature increases.

In a quiescent state, the approach to saturation and pressure increase of a vapor space with gasoline vapors is a slow process. Since hydrocarbon vapors are heavier than air and diffusion is slow, a saturated blanket of vapor initially forms over the liquid surface, decreasing the driving force for further vaporization. Also, with evaporation of the lighter hydrocarbon molecules, the tendency of the components in the stagnant surface to vaporize decreases. Thus, the degree of saturation in the overall gas space of a tank can be decreased by minimizing liquid surface and vapor space mixing during the filling operation.

Splash loading not only creates liquid droplets which can be entrained in the outgoing effluent and exposes fresh liquid surfaces, but results in mixing of the vapor space as well. This mixing of the vapors disturbs the saturated blanket near the liquid surface, increasing the driving force for further vaporization. Hydrocarbon emissions under splash filling conditions can significantly exceed that calculated by assuming saturation (Reference 4-d).

Another factor which can affect the quantity of hydrocarbons emitted is the interval between draining and filling. When a tank is drained and immediately refilled, the air drawn into the tank during draining may be expelled with relatively little hydrocarbon content. In a tank allowed to sit after draining, the air drawn into the vapor space becomes saturated with hydrocarbons, thus, increasing pressure (and emissions) and resulting in the maximum loss of vapor during refilling.

Another operational procedure which may increase working losses is the small sequential withdrawals of gasoline from a storage tank over a period of several days rather than one continuous large withdrawal. After a small withdrawal, the post-transfer emissions caused by evaporation tend to be high in hydrocarbons since little air is ingested during the withdrawal. After a large withdrawal, the initial post transfer emissions are low in hydrocarbons since large amounts of air are ingested during the withdrawal.

4.1.3 Miscellaneous Losses

Miscellaneous losses have been found to be highly variable. These losses include spillage, liquid and vapor leakage and operational losses which occur when opening tank hatches for visual inspection or measuring liquid levels with dip sticks. Leakage can occur and has been observed at dry breaks, pressure vacuum valves, hatches, manholes, pump seals, shut-off valves and piping joints. It has been visually observed that some spillage (on the order of half liter) occurs when connecting and disconnecting transfer lines. Visible liquid leakage at dry breaks (few milliliters of gasoline) was observed from the connections after transfer. Opening of hatches generally does not occur during transfer.

4.2 EMISSION ESTIMATES

4.2.1 Breathing Losses (Storage Tanks)

Storage tank breathing losses can be estimated from an equation converted from an API formula (Reference 4-a) derived for gasoline and given in a Radian Report (Reference 4-f) as follows:

$$L = 2.21 \times 10^{-4} M \left(\frac{P}{14.7 - P}\right)^{0.68} D^{1.73} H^{0.51} T^{0.50} F_p CK \qquad (4\text{-}1)$$

Where:

L = Fixed roof breathing loss (lb/day)

M = Molecular weight of vapors lost (lb/lb mole)

P = True vapor pressure of liquid at bulk liquid temperature (psia)

D = Tank diameter (ft)

H = Average vapor space height (ft)

T = Average daily ambient temperature change (°F)

F_p = Paint factor (dimensionless)

C = Adjustment factor for small diameter tanks (dimensionless)

K = Adjustment factor dependent on product stored (dimensionless = 1 for gasoline)

This equation can be converted to metric as follows for gasoline:

$$L = 1.927 \times 10^{-3} M \left(\frac{P}{101{,}325 - P}\right)^{0.68} D^{1.73} H^{0.51} T^{0.50} F_p C \qquad (4\text{-}2)$$

Where:

L = Fixed roof breathing loss (kg/day)

M = Molecular weight of vapors lost (gm/gm mole)

P = True vapor pressure at bulk liquid temperature (newtons/sq meter)

D = Tank diameter (meter)

H = Average vapor space height (meter)

T = Average daily ambient temperature change (°C)

F_p = Paint factor (dimensionless)

C = Adjustment factor for small diameter tanks (dimensionless)

For a typical bulk plant, the values for these factors are:

M = 66 (Reference 4-f)

P = 42,800 newtons/sq meter (6.2 psia, Reference 4-f RVP-10 gasoline at 70°F)

D = 3.2 meter (10.5 ft survey average)

H = 4.0 meter (13 ft, 1/2 of survey average height)

T = 8.3°C (15°F, Reference 4-b)

F_p = 1.24 (Reference 4-a for white roof and specular aluminum shell in poor condition, condition based on survey observations)

C = 0.55 (Reference 4-a,f for given D)

With these values, a typical bulk plant breathing loss is 3 kg/day (6.7 lb/day) per tank. The resultant total gasoline loss due to breathing is 9 kg/day (20 lb/day) using three gasoline tanks per typical bulk plant. This type of loss occurs whenever gasoline is stored in a tank.

The empirical test data that this breathing loss formula was derived from (Reference 4-a) indicates observed breathing loss may vary by a factor of two from the calculated loss. Data was correlated on a log-log basis. The primary reason given in Reference 4-a for this wide spread is uncorrelatable weather conditions, such as amount of sunshine, cloudiness, and precipitation.

Further analysis of "uncorrelatable weather conditions" indicates that these conditions may be critical to estimating loss from specific tanks. This is because the tank temperature changes resulting from daily weather conditions are the primary cause of breathing losses. The daily temperature fluctuations of the tank materials in the storage tanks is due to heat being transferred to and from the tanks which depends upon ambient temperature changes (correlated in formula), the exposed surface area of the tank (partially correlated by D in formula), and reflectivity of the surface (correlated by paint factor in formula). However, the amount of radiation received (adding further to the daily temperature rise of tank), wind velocity (wind increases heat transfer between tank and air), tank wall construction (affects heat transfers to stored materials), precipitation (heat transfer is now from water or ice to stored materials), and tank supports and appendages (additional source of heat transfer) is not accounted for in the formula. Thus, although Reference 4-a indicates that the formula will not deviate from actual average breathing loss over a long period of time by more than 10%, the average breathing loss from a specific bulk plant may be significantly underestimated or overestimated by this formula.

Another factor which is not accounted for in this correlation is the interrelationship with filling and draining. Only non-working tank breathing loss data was used to derive the formula. Ullage space in non-working tanks tend to approach saturation. The ullage space in working (filling and draining) tanks may not have sufficient time to approach saturation conditions. Therefore, breathing losses may be overestimated during working times. If slow tank filling could be accomplished during ambient temperature cooling times (late afternoon), working losses may be reduced. If tank draining can be slowly accomplished during ambient temperature rise times, breathing losses can be reduced. The difficulty with this control approach is when one tank is filling, another is normally draining. To further illustrate the interrelationship between breathing and working losses, a breathing loss control system could be devised to pump in liquid during cooling times (on pressure decrease) and pump out liquid during heating times (on pressure increase). The difficulty again is that pumped liquid may accomplish the exact reverse in companion receiver tank.

Another significant factor in the estimation of breathing losses is the operating pressure range of the storage tanks. The above calculated breathing losses apply to storage tanks operating with little or no measurable vacuum or pressure settings on the vent valve. A relationship between vent settings and a calculated breathing loss

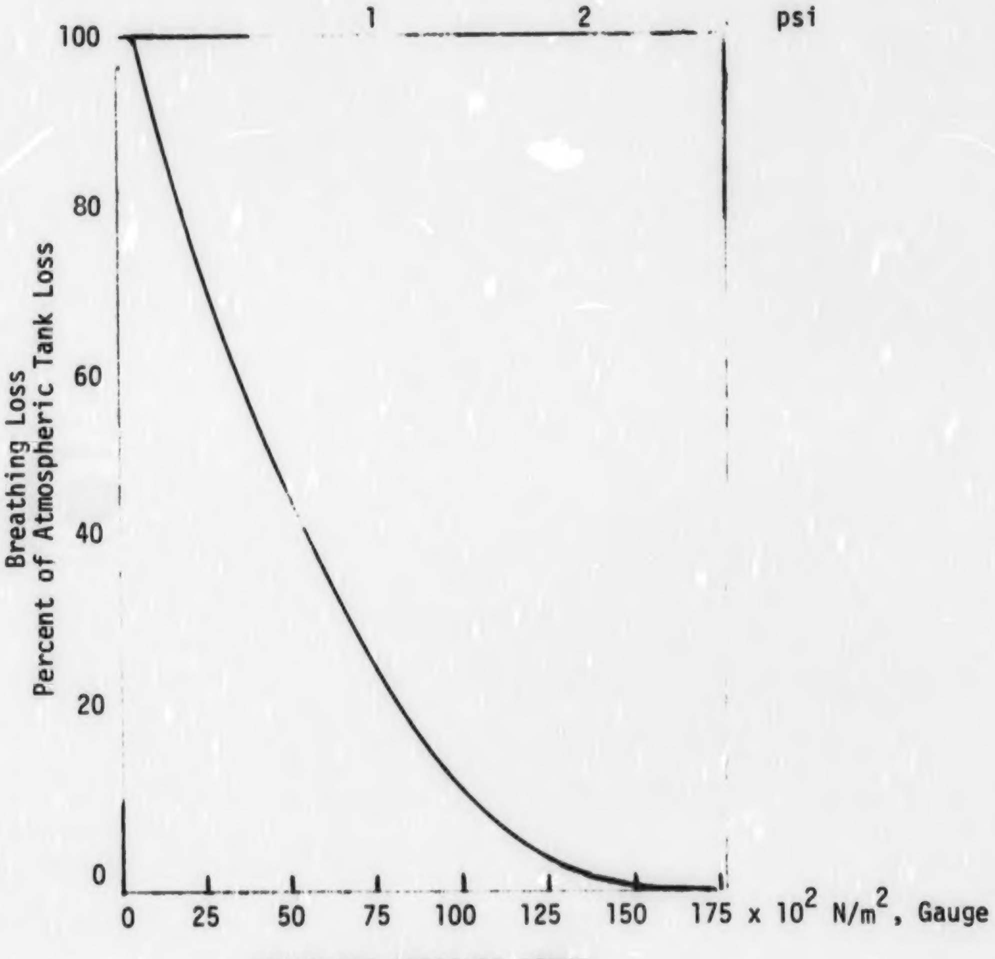

Figure 4-1. RELATIONSHIP OF TANK OPERATING PRESSURE RANGE TO BREATHING LOSS.

NOTE: Source is Reference 4-c, reproduced with SI pressure units.

is shown in Figure 4-1. This approximate relationship was suggested by API (Reference 4-c) for vent settings in the range of 0 to 17,000 newtons/m^2 gauge (0 to 2.5 psig).

Emissions due to evaporation and pressure increase after gasoline withdrawal are not considered in Equation 4-1,2 but are included as a part of the working loss equations since such losses are functions of throughput and the procedures by which gasoline is withdrawn from the tanks.

Other factors in the breathing loss equation are true vapor pressure, tank diameter and ullage height and paint factor. The true vapor pressure of gasoline is a measure of the tendency for gasoline to evaporate at the given temperature. Thus, the higher the vapor pressure, the greater the potential losses. Values of the true vapor pressure of gasoline at specified temperatures can be obtained from References 4-a,b,f as a function of the Reid Vapor Pressure (RVP) of the gasoline. The RVP is a common method for characterizing gasoline in the petroleum industry.

Tank diameter and height of vapor space are parameters of the vapor space volume. Since a larger volume results in more breathing for the same ratio of expansion and contraction, a larger vapor volume results in larger losses.

The color and reflective quality of the tank affects radiative heat transfer and, as a consequence, breathing losses. Included as a paint factor in Equation 4-1, this factor can vary from 1.0 for good quality white paint to 1.5 for a medium gray color. These factors can be obtained from References 4-a,b,f as a function of the color, appearance and quality of these tank surfaces.

4.2.2 Working Losses (Storage Tanks)

The primary cause of hydrocarbon emissions during the transfer of gasoline (working losses) is the displacement of air-hydrocarbon vapors in the tank being filled with liquid gasoline. The amount and concentration of hydrocarbon vapors in the vapor space is a function of tank temperature, pressure, gasoline properties, tank geometry and past working of tank. The basic fixed roof working loss equation, derived from API (Reference 4-a) assumes saturated vapor in tanks unless "turnovers" (indication of past working of tank) exceed a fixed amount. Working loss equation as modified to SI units from API (Reference 4-a) is:

$$W = 4.3 \times 10^{-8}\, dPK_T \qquad (4\text{-}3a)$$

and Radian (Reference 4-f) equation converted to SI units is:

$$W = 4.1 \times 10^{-7}\, MPK_T \qquad (4\text{-}3b)$$

Where:

W = Working loss (kg/1000 liters)
d = Gasoline condensed vapor density (kg/m^3)
M = Molecular weight of vapor in storage tank (gm/gm mole)
P = True vapor pressure of liquid (newtons/m^2 absolute)
K_T = Turnover factor (dimensionless)

The factor K_T is a function of tank turnovers per year which is equal to the annual throughput divided by the tank capacity. It is essentially a measure of how close the tank vapor space approaches saturated conditions. For 36 tank turnovers per year or less it is assumed by Reference 4-a that the vapor space saturates and K_T is taken as unity. Losses would then increase linearly with increase in throughput. As the frequency of turnovers exceeds 36, K_T then assumes the form:

$$K_T = \frac{180 + N}{6N} \qquad (4\text{-}4)$$

Where: N = throughput in turnover per year. Turnovers at typical bulk plants are less than 36, therefore, $K_T = 1$ for typical small bulk plant operations as evaluated for this project.

The assumption of saturated conditions is critical to the applicability of this equation. Analysis of actual tank conditions is complex, however, API (Reference 4-a) indicates this formula is "based on experience." Reference 4-a does not show data that "experience" is based upon. This formula applies to a range of storage tanks that are, for the most part, much larger than typical small bulk plant storage tanks (Reference 4-a, Appendix II). These larger tanks would tend to take longer to reach saturation, assuming all other factors equal, based on diffusion. Underground tanks may be splash loaded which may not only quickly saturate the vapor space, but entrain liquid droplets in displaced vapors. Splash loading for tank trucks has been shown to significantly affect emissions (Reference 4-f), but no data was located for storage tanks. These factors would tend to increase actual working losses at a small bulk plant when compared to calculated working losses, but magnitude of these effects are unknown.

A further factor, discussed in Reference 4-a, which may increase working losses is due to the evaporation of vapors into fresh air after draining. Subsequent evaporation will increase the tank pressure tending to expell vapors. The concentration of hydrocarbon vapors expelled will depend upon, among other factors, the amount withdrawn. Reference 4-a indicates that many small incremental withdrawals can theoretically result in actual emissions larger than calculated by a factor exceeding three. A few large withdrawals may theoretically result in actual emissions larger than calculated by a factor of less than two. The typical bulk plant operation approaches the small incremental withdrawal case with larger theoretical emissions.

Actual bulk plant emissions due to this post withdrawal evaporation factor will probably be somewhat masked by breathing losses. For example, after a withdrawal in the late afternoon, the tank temperatures (and pressures and saturated hydrocarbon concentrations) will be decreasing. Thus, the air drawn in by the small withdrawal may only replace air that would have been drawn in by tank breathing.

However, if theoretical assumptions are valid (vapor space reaches saturation prior to succeeding small incremental withdrawals and perfect mixing of vapors) and breathing loss is negligible (underground tanks) or withdrawals and all evaporation occurs during temperature rise portion of breathing cycle, an evaporative factor, F_A must be added to the calculation and can be theoretically defined as follows (Reference 4-a):

$$\frac{1}{1 - P/101{,}325} \qquad (4\text{-}5)$$

Where:

F_A = Factor in working loss (dimensionless)

P = True vapor pressure, newtons/meter^2

Although no data are given, the true value of F_A will be somewhere between one and the theoretical value given above because of potential masking by breathing mechanism and non-achievement of assumed conditions.

An additional factor for bulk plant storage tanks in which pressure-vacuum vent settings can be fixed is a vent factor, F_V (Reference 4-c), which can be applied to Equation 4-3. This factor reduces the calculated emissions based upon the operating pressure range of the tank. Assumptions are that no change in temperature or true vapor pressure of the gasoline takes place during the filling process and that filling starts at slightly less than atmospheric pressure with a hydrocarbon-saturated vapor space. F_V then becomes (Reference 4-c):

$$F_V = \frac{P_A + P_V - P}{P_A + P_p - P} \qquad (4\text{-}6)$$

Where:

F_V = Vent setting correction factor for filling

P_A = Atmospheric pressure (abs)

P_V = Vacuum settings (gauge, typically <0)

P_p = Pressure setting (gauge)

P = True vapor pressure (abs)

Note: Use consistent pressure values

The applicability of this theoretical equation is dependent upon the assumptions. The filling conditions assumed (filling occurs at slightly less than atmospheric pressure) will occur immediately after a withdrawal, drawing air into the tank. If filling occurs later, evaporation and breathing factors will raise the tank pressure. In the extreme, if the tank pressure is at maximum (vent pressure setting), $F_V = 1$. Reference 4-c indicates applicability of F_V equation is limited to "that portion of the pressure range which is surplus to the range required to prevent breathing loss." Typical bulk plant operating pressure range does not prevent breathing loss. Thus, again although no data exists, F_V probably lies somewhere between the theoretical value calculated and one.

Working losses for specific bulk plants can then be calculated by using the applicable factors such that:

$$W = 4.3 \times 10^{-8}\ dPK_T\ F_A\ F_V \qquad (4\text{-}7a)$$

or converted to Radian parameters

$$W = 4.1 \times 10^{-7}\ MPK_T\ F_A\ F_V \qquad (4\text{-}7b)$$

Where:

W = Working loss (kg/1000 liters)

d = Gasoline condensed vapor density (kg/m^3)

M = Molecular weight of hydrocarbon vapors in storage tank (gm/gm mole)

P = True average vapor pressure of liquid (newtons/m^2 absolute)

K_T = Turnover factor (dimensionless)

F_A = Evaporative factor (dimensionless)

F_V = Vent factor (dimensionless)

As indicated above, the values of the dimensionless factors K_T, F_A and F_V when applied to bulk plants are questionable. Reference 4-a implies that the K_T factor represents a lumped factor which adequately represents all the factors when used in conjunction with the loss equation assuming saturated vapor conditions. Although data is lacking, actual emissions from a bulk plant may be somewhat larger than calculated (setting $K_T\ F_A\ F_V = 1$) because of small size storage tanks, small incremental withdrawals and small operating pressure range. However, without further analysis and data, supportable values for these factors can not be calculated.

Lacking more applicable values for factors applied to a typical bulk plant, API's implied approximation (setting $K_T\ F_A\ F_V = 1$) will be used. This will probably underestimate actual emissions but significance of underestimation is unknown.

For a typical bulk plant,

$M = 66$ (Reference 4-f for RVP-10 gasoline)
$d = 612\ kg/m^3$ (5.1 lb/gal, Reference 4-f for RVP-10 gasoline)
$P = 42{,}800\ N/m^2$ (6.2 psia, Reference 4-f for RVP-10 gasoline at 70°F)

Then W = 1.13 kg/1000 l (9.4 lb/1000 gal) or 1.16 kg/1000 l (9.7 lb/1000 gal) depending on the use of equation 4-7a or 4-7b respectively. The estimated total uncorrected working loss for a typical bulk plant studied herein is approximately 17 kg (37.5 lb) per day.

4.2.3 Truck Working Losses

Radian (Reference 4-f) recommends the use of the ideal gas law with a saturation factor S to estimate hydrocarbon losses from the loading of gasoline onto trucks. Taking an ideal gas, one gram mole of a vapor occupies 22.4 liters at 101,325 newtons/m^2 (1 atm) and 273°K.

Then:

$$W_L = M \left(\frac{P}{101,325}\right) \left(\frac{1}{22.4}\right) \left(\frac{273}{T}\right) S \qquad (4\text{-}8)$$

$$= 1.2 \times 10^{-4} \frac{MPS}{T}$$

Where:

W_L = Loading loss (kg/1000 liter)

P = True vapor pressure of gasoline (newtons/m^2)

M = Molecular weight

T = Temperature (°K)

S = Saturation factor (dimensionless) where S = 1 for saturated; $S > 1$ liquid entrainment; $S < 1$ not saturated.

Suggested values of saturation factors (S) which relate the quantity of hydrocarbon vapor in the expelled gas to the saturated value are given in Table 4-1. These values were reproduced from Reference 4-f.

Taking the values used before:

M = 66

P = 42,800 N/m^2 (6.2 psia)

T = 294°K (70°F)

S = 0.6 (Table 4-1, submerged loading and dedicated service)

W_L = 0.69 kg/1000 liter (5.8 lb/1000 gal) which is equal to a loss of 10.4 kg (23 lb) of gasoline per day for our typical bulk plant truck loading operations assuming submerged filling without a vapor balance system.

Table 4-1

S FACTORS FOR CALCULATING UNCONTROLLED GASOLINE TANK TRUCK LOSSES

	S
Submerged Loading(2)	
Clean cargo tank	0.50
Normal dedicated service(4)	0.60
Dedicated, vapor balance service(5)	1.0
Splash Loading(3)	
Clean cargo tank	1.45
Normal dedicated service(4)	1.45
Dedicated, vapor balance service(5)	1.0

(1) Values reproduced from Radian report (Ref. 4-f)

(2) Gasoline loaded near bottom of tank

(3) Gasoline dumped in from top of tank

(4) Tank used for one product only

(5) Note (4) plus vapors returned to storage tank

The form of the equation to calculate truck working losses differs from the tank working loss equation. The factor S seems to replace K_T, F_A and F_V factors. K_T and F_A factors are dependent upon time between transfer operations and this time is typically much less for tank trucks than for storage tanks. Thus the value for S generally less than one, except for splash loading (with entrainment of liquid droplets) seems reasonable. However, without more data analysis, the validity of the factor to bulk plant account trucks is unknown. Again, some factors tend to indicate that overall truck factor may be low for bulk plant application. These factors include: small size of tank trucks leading to reduced time to reach saturation, tank truck cargo compartments may not be empty upon refilling and off-road deliveries may quickly saturate vapor space by agitation. Again lacking more applicable values for S, Reference 4-f approximations will be used.

The addition of the factor T in the truck working loss equation when compared to the tank working loss equation is more difficult to explain. The storage tank equation essentially assumes a nominal tank temperature, whereas the tank truck equation includes it as a variable. Although the inclusion of temperature as a variable is more correct, the effect of normal variations in temperature alone (independent of true vapor pressure) is small, thus, a change of 15°C (37°F) is required to change calculated emissions by 5%. Thus, the inclusion of a temperature factor by Radian in the truck working loss equation seems to be a minor refinement in accuracy, yielding little total improvement, given the inherent limitations to the accuracy of the "S" factor.

4.2.4 Truck Breathing Losses

No empirical or theoretical calculations were found to estimate truck breathing losses. However, the factors that cause breathing losses in storage tanks, primarily temperature variations, will also cause breathing losses in trucks.

Primary factors that tend to reduce truck breathing losses, when compared to storage tank losses, are small tank capacity and the short gasoline residence time in trucks between transfers. Factors which tend to increase losses, when compared to storage tank breathing losses, are improved heat transfer (high convective heat transfer coefficient when truck is moving) and agitation (tending to quickly saturate vapor space). Reference 4-g indicates that a pressure spike may occur upon first movement of the truck after filling, and venting and/or leakage of the pressure in truck may also occur. Amount of emissions were not measured, however. Thus, contribution of truck breathing losses to the emissions total is unknown.

4.2.5 Miscellaneous

Emission factor equations are not available for the calculation or estimation of leaks and spills. However, Reference 4-d gives a value of 570 liters (150 gal) per month for leakage loss as an average value for bulk plants with a throughput of approximately 45,000 liters (12,000 gal) per day.

Some of these losses are directly proportional to throughput while others are independent of throughput. Spillage, leakage at points only exposed to vapors or liquid during transfer, and leakage primarily caused by liquid pump pressurization would be directly related to throughput. Other miscellaneous losses, such as daily opening of tank hatches, and leakage at points constantly exposed to liquid or vapors would be independent of throughput. Other types of leakage, such as pump seals, would be somewhat dependent upon throughput. Based on visual observations, the majority of miscellaneous emissions appear to be at least somewhat proportional to throughput (loss when connecting and disconnecting lines, pump related losses and spillage).

Using a direct ratio of Reference 4-d value, miscellaneous losses would be 190 liters per month (127 kg/month or 380 lb/month assuming a density of 671 kg/m^3 or 5.6 lb/gal) for a typical bulk plant with a daily throughput of 15,000 liters (4,000 gal).

4.2.6 Summary of Emissions

Estimates of emissions for three sizes of small bulk plants using the calculations discussed herein is presented in Table 4-2.

Breathing losses are based on a 365 day year while working (loading) losses are based on a 250 day year. For the same throughput, the difference between the truck and the storage tank working losses is essentially due to the saturation factor used for truck-loading. Emissions from customer tank working and breathing losses are not included.

The total emissions are listed as a minimum. This is due to (1) Unknown, but positive truck breathing losses, (2) storage tank breathing loss estimate may be low due to API log correlation of data base, and (3) working losses may be low due to high F_A and F_V factors. The quantitative effect of these factors is uncertain.

4.3 DISCUSSION OF VARIOUS EMISSION EQUATIONS

Equations for the estimation of hydrocarbon losses from fixed roof gasoline storage tanks were initially developed by the American Petroleum Institute (API). API equations give answers in barrels which represented the liquefied volume of the lost vapors. In AP-42, the equations were converted to give answers in pounds of fluid lost. Radian Corporation was contracted by EPA to revise and upgrade AP-42 emission factors (Reference 4-f). One correction required in the AP-42 is the change in definition of the density factor from the density of the liquid in storage to the liquid density of the lost vapors. Another corrects K_T for turnovers less than 36. Radian Corporation also utilizes the ratio of $d/M \approx 0.08$

d = Liquid density of vapor lost (lb/gal)
M = Molecular weight of vapor lost

to convert the API based equation to a form utilizing the molecular weight of the vapors lost as a factor.

TABLE 4-2

UNCONTROLLED EMISSIONS RELATED TO A BULK PLANT

GASOLINE LOSS (LITERS)

BULK PLANT DAILY THROUGHPUT	3,800 LITERS (1,000 GALLONS)		15,000 LITERS (4,000 GALLONS)		76,000 LITERS (20,000 GALLONS)	
TYPE OF LOSS	ANNUAL	WORKING DAY	ANNUAL	WORKING DAY	ANNUAL	WORKING DAY
STORAGE TANK						
BREATHING	5,430	14.9	5,430	14.9	5,430	14.9
WORKING	1,740	6.9	6,940	27.8	34,700	138.8
ACCOUNT TRUCK						
BREATHING	?	?	?	?	?	?
WORKING	1,070	4.3	4,270	17.1	21,350	81.4
MISCELLANEOUS	570	2.3	2,270	9.1	11,400	45.6
MIN. TOTAL LOSS	8,810	28.4	18,910	68.9	72,880	280.7
THROUGHPUT	950,000	3,800	3,750,000	15,000	19,000,000	76,000
MIN. LOSS (% OF THROUGHPUT)	0.93	0.75	0.50	0.46	0.38	0.37

NOTE: Use 250 days per year for all losses except for storage tank breathing losses (365 days/year).

Equations from all three sources, API (Reference 4-a), AP-42 (Reference 4-b) and Radian (Reference 4-f), can be applied to other than gasoline storage by using the proper dimensionless factors given in the references for the specific product stored. Under identical conditions of evaluation, answers for either breathing losses or working losses of gasoline for fixed-roof tanks should be similar regardless of the source of the emission equations. Any discrepancies would arise from conversions such as the Radian equations which utilize a somewhat variable ratio, d/M, as constant to convert the emission equations for use with molecular weights.

On a theoretical basis, equation 4-8 can replace equation 4-3. The K_T factor in equation 4-3 actually represents S, the saturation factor, and the coefficient in 4-3 includes the absolute temperature for a temperature of 20°C (68°F). In essence, for estimation of gasoline emissions, equations from API, AP-42 or Radian can be used interchangeably based on the ease of obtaining the molecular weight or the liquefied density of the gasoline vapors lost.

REFERENCES

4-a API Bulletin 2518, "Evaporation Loss from Fixed Roof Tanks," American Petroleum Institute, June, 1962.

4-b AP-42, Compilation of Air Pollutant Emission Factors, 4.3-4, U.S. Environmental Protection Agency, July, 1973.

4-c API Bulletin 2516, "Evaporation Loss from Low-Pressure Tanks," American Petroleum Institute, March, 1962.

4-d API Bulletin 1623, "Recommended Good Practices for Bulk Liquid-Loss Control in Terminals and Depots," American Petroleum Institute, June, 1972.

4-e API, Petroleum Safety Data 2210, "Flame Arresters for Tank Vents," American Petroleum Institute, May, 1976.

4-f Draft Final Report, "Revision of Evaporative Hydrocarbon Emission Factors," Radian No. 100-086-01, Radian Corporation, June 15, 1976.

4-g Preliminary Draft of Delivery Tank Leak and Pressure Tests, California Air Resources Board, dated 5/26/76.

5. EMISSION CONTROL TECHNIQUES

5.1 INTRODUCTION

Control of gasoline breathing and/or working losses resulting from the storage and handling of gasoline may be accomplished by several techniques. Some of these techniques may not have been previously applied to bulk plants but have been proposed or applied to the recovery of hydrocarbon vapors at other locations. The techniques discussed include: submerged fill, pressurized tanks, balance systems, bladders and various processing systems. Processing systems convert a portion of the hydrocarbon vapors to either recoverable liquids or nonreactive gases.

All these techniques, except for submerged fill, are capable of adequately controlling a minimum of 90% of either breathing or working losses. Submerged fill is included in the discussion because it has been required by regulations and significantly reduces transfer losses.

The efficiency, initial cost, development status and bulk plant applicability of each alternative is briefly reviewed. The purpose of the review is to (1) present an overview of available control methods and (2) allow selection of alternatives for further review. Since some of the alternatives have not been applied to bulk plants, many of the factors of efficiency, cost, development and applicability are based upon engineering judgment.

Combinations of control techniques are briefly reviewed. Engineering judgment is also employed in the evaluation of factors.

The selected control alternatives and combinations are further defined and discussed. Rationale for selection is also reviewed. Integration with techniques to control fugitive emissions is briefly discussed.

5.2 POTENTIAL EMISSION CONTROL SYSTEMS

Table 5-1 presents an overview of the results of evaluations of the various emission control measures which are discussed in the remainder of this section. Expected efficiencies are rated, based on engineering judgment in most cases, either as A (better than 90% efficiency), B (some value but not up to 90% efficiency) or C (little apparent effect, probably not over 10% reduction of vapor losses). Also shown in Table 5-1 are estimated price ranges, in terms of A (less than $5,000); B (less than $50,000 but probably more than $5,000), and C (probably more than $50,000). Further information relates to the present availability of each suggested control measure in terms of the degree of development judged to be still necessary and to the applicability of the measure or system specifically to the conditions of bulk plant operation. Other relevant remarks are listed in the final column.

The information on which Table 5-1 is based is discussed in further detail in following sections.

5.2.1 Submerged Fill

Submerged fill is the introduction of liquid gasoline into the tank being filled with the transfer line outlet being below the liquid surface. This is compared to splash loading, where the transfer line outlet is at the top of the tank. Submerged filling minimizes droplet entrainment, added vaporization and turbulence. If a fill port is located at the tank top, submerged fill is accomplished by either extending the nozzle (commonly referred to as stingers) or permanently attaching to the fill port a pipe extending to within 15 cm (6 inches) of the tank bottom. This permanent installation is commonly referred to as a drop tube.

Aboveground storage tanks normally include submerged fill. Submerged fill for underground storage tanks can be accomplished by attaching a pipe to the fill port. These installations are common on underground tanks in surveyed areas.

CONCEPT	DERIVATIVES	ANTICIPATED EFFICIENCY (%)(a)										REMARKS
		Storage Tank		Incoming(b) Truck	Outgoing Truck		Customer Tanks		Estimated Initial Cost ($1,000)	Development Req'd.	Bulk Plant Applicability	
		Breathing	Working	Breathing	Working	Breathing	Breathing	Working				
SUBMERGED FILL	1) Storage Tank	C	B	--	--	--	--	--	<5	No	Good	Exists in many areas and only applicable for underground tanks. No further consideration.
	2) Trucks	--	--	C	B	C	--	--	<5	No	Good	
	3) Customer Tanks	--	--	--	--	--	C	B	<5	Little	Good-Fair	"Spit Back" problems.
INCREASE PRESSURE CAPABILITY	1) Increase Storage Tank Pressure Vacuum Valve Set Point	B	C	--	--	--	--	--	<5	Little	Fair-Good	Old tanks may require repair or replacement.
	2) Install Valve on Open Storage Tank Vent	B	C	--	--	--	--	--	<5	Little	Fair	Applicable to underground tanks. Changes to codes may be required.
	3) Restrict Open Vent	C	C	--	--	--	--	--	<5	Little	Fair	Same as above.
	4) Increase Truck Pressure Vacuum Valve Set Point	--	--	B	C	B	--	--	50	Little	Fair	Old trucks may require repair or replacement.
	5) Increase (or install) Presure Vacuum Set Point on Customer Tanks	--	--	--	--	--	B	C	<50	Little	Fair	Old tanks may require repair or replacement.
BALANCE	1) Storage Tank to Incoming Truck Vapor Line	C	A	C	--	--	--	--	<50	No	Good	Old tanks may require repair to stop leakage.
	2) Outgoing Truck to Storage Tank Vapor Line	C	C	--	A	C	--	--	<50	No	Good	Old trucks may require repair and bottom loading normally included.
	3) Customer Tank to Outgoing Truck Vapor Line	--	--	--	C	C	C	A	<50	Little	Fair-Good	Old tanks may require repair to stop leakage.

CONCEPT	DERIVATIVES	ANTICIPATED EFFICIENCY (%)[a] Storage Tank		Incoming[b] Truck	Outgoing Truck		Customer Tanks		Estimated Initial Cost ($1,000)	Development Req'd.	Bulk Plant Applicability	REMARKS
		Breathing	Working	Breathing	Working	Breathing	Breathing	Working				
ADSORPTION	1) Storage Tank Vent	A	A	--	--	--	--	--	<50	Some	Fair	Regeneration Req'd. Maintenance questionable.
	2) Truck Vent	--	--	A	A	A	--	--	<50	Yes	Fair	Same as above.
	3) Customer Tank Vent	--	--	--	--	--	A	A	>50	Yes	Fair	Same as above.
ABSORPTION	1) Storage Tank	A	A	--	--	--	--	--	<50	Yes	Fair-Poor	Requires absorbant use or regeneration after abosrption.
	2) Truck Vent	--	--	A	A	A	--	--	<50	Yes	Poor	Same as above plus possible lack of absorbant on truck.
	3) Customer Tank Vent	--	--	--	--	--	A	A	>50	Yes	Poor	Same as above.
REFRIGERATION	1) Storage Tank	A	B	--	C	C	--	--	<50	Some	Fair-Good	Significant operating costs. Aboveground storage tank is primarily application.
	2) Intermittent HC Condensing of Vented Storage Tank Vapors	A	A	--	C	C	--	--	<50	Yes	Fair-Good	Significant operating costs.
	3) Truck Product	C	C	A	B	A	C	C	<50	Yes	Fair-Good	Same as above.
	4) Intermittent HC Condensing of Vented Truck Tank Vapors	C	C	A	A	A	C	C	<50	Yes	Fair-Good	Same as above.
	5) Cooling Customer Tank Product	--	--	--	--	--	A	B	>50	Yes	Poor	Same as above plus maintenance doubtful.
	6) Intermittent HC Condensing of Vented Customer Tank Vapors	--	--	--	--	--	A	A	>50	Yes	Poor	Same as above.

CONCEPT	DERIVATIVES	ANTICIPATED EFFICIENCY (%)[a]										REMARKS
		Storage Tank		Incoming Truck[b]	Outgoing Truck		Customer Tanks		Estimated Initial Cost ($1,000)	Development Req'd.	Bulk Plant Applicability	
		Breathing	Working	Breathing	Working	Breathing	Breathing	Working				
OXIDATION	1) Flare Stack Storage Tank Vent	A	A	--	--	--	--	--	<50	Some	Poor	Very strong safety objections. No further considerations.
	2) Incineration Catalyst, Storage Tank Vent	A	A	--	--	--	--	--	<50	Some	Poor	Strong safety objections.
COMPRESSION-REFRIGERATION-CONDENSATION-(CRC)	Storage Tank Vent	A	A	--	--	--	--	--	>50	Little	Fair	Significant operating costs. Maintenance questionable.
BLADDER	1) Retrofit Storage Tanks	A	A	--	--	--	--	--	>50	Yes	Poor	Old tanks may require repair or replacement. Bladder leakage problems.
	2) Retrofit Trucks	--	--	A	A	A	--	--	>50	Yes	Poor	Same (for trucks) as above.
	3) Retrofit Customer Tanks	--	--	--	--	--	A	A	>50	Yes	Poor	Same (for tanks) as above.
REFORMING	Convert/Condense Heavy HC Vented Vapors Using Catalyst	?	?	--	--	--	--	--	>50	Yes	Poor	No further consideration.
CRACKING	Convert Vented Vaport to Lighter HC Vapors Using Catalyst or Radiation	?	?	--	--	--	--	--	>50	Yes	Poor	No further consideration.
REDUCE TANK PRESSURE	1) Insulation	C	--	C	--	C	C	--	<50	Yes	?	
	2) Vapor or Liquid Holding Tanks	B	C	A	C	A	A	C	>50	Yes	?	

DEFINITIONS:

Development Terms	No = Presently applied to bulk plants with few problems, Little = Presently applied to prototype bulk plants or directly related application with few problems, Some = Presently applied to prototype or related Petroleum Marketing application; Yes = No known present application or problems associated with application.
Applicability Terms	Good = No technical problems expected; Fair = Some major repair or replacement of equipment may be required; Poor = Major installation or maintenance beyond the capability of typical plant.

-- Not Applicable

NOTE: (a) Control of miscellaneous or fugitive emissions not considered since primary control methods involve operation of plant.
(b) Incoming truck working losses not considered since primary control would occur at supply source.

Efficiency Terms: A = better than 90% control
B = substantial efficiency; better than 10% reduction of vapors, but less than 90%
C = little or no efficiency; less than 10% reduction of vapors

Bottom loaded trucks by definition include submerged filling. Top loaded trucks utilize an extension such as a pipe or flexible hose facility loading arm. The extension may be permanently attached if the loading arm can be raised sufficiently to clear the trucks. No development is necessary except for customer tanks. The major problem encountered, spitback from customer tanks, can be overcome by inserting a long tube-like nozzle (a stinger) through the filling pipe.

5.2.2 Pressurized Tanks

Increasing the pressure settings of storage tank pressure-vacuum valves will result in a reduction of breathing losses. However, the storage tank limitations (Reference 5-a limits operating pressure on atmospheric tanks to 1 psig) generally do not allow 90% reduction in emissions. Figure 4-1 illustrates the amount of breathing loss reduction versus the operating pressure range. Working losses can also be reduced by increasing the operating pressure range, but amount of working loss reduction is small since pressures required for control are large. For example, to preclude emissions from an empty tank being one half filled at constant temperature, operating pressure range must be in the order of 100,000 N/m^2 (one atmosphere) gauge.

Methods used to effect the increase in operating pressure range are either to replace the pressure vacuum valve or modify the settings of the existing valves. Typical valves such as OPW 95-UT, are weighted rather than spring loaded. This design allows relatively easy adjustments within the capability of the valve.

Difficulties associated with increasing the operating pressure range involve primarily safety and leakage. One contractor estimated that one out of three storage tanks modified required welding to stop leakage. Although retesting (including hydrostatic proof tests) of certain types of welded tanks is required after repairs (Reference

5-b), most bulk plant tanks would be exempt from this requirement. The age of storage tanks is another factor. The amount of rust formation and other age related degradation (corrosion due to storing high sulfur fuels, for example) of the storage tanks is generally unknown. Increasing the operating pressure under these conditions may require inspection and/or non-destructive testing.

5.2.3 Balance System

Probably the most common vapor recovery system currently in use is the vapor balance system. It affects working losses only. A pipeline between the vapor spaces of the truck and storage tanks essentially creates a closed system permitting the vapor spaces of the tank being filled and the tank being emptied to balance with each other. The net effect of the system is to transfer vapor displaced by liquid into the tank in which draining of the liquid creates additional vapor space. This prevents the compression and expansion of vapor spaces which would otherwise occur in a filling operation. If a system is leak tight, very little or no air is drawn into the system and venting due to compression also is reduced substantially. The system is applicable to underground and above-ground storage facilities equipped with either bottom or top loading.

The vapor return piping is generally 5 to 8 cm (2 to 3 inches) in nominal diameter with gasoline tanks manifolded together. Piping is sloped on horizontal runs to drain any condensate. The no lead tank may have special protection against contamination from leaded gasoline vapors. Non-metallic piping may be used if local codes allow. Costs to install vary as a function of line lengths, access and ability to seal old tanks against leakage. Efficiency of the system is also strongly dependent upon leakage.

Costs to install balance systems for transfers of gasoline are detailed in Section 6. Average cost is a few thousand dollars for incoming transfer of gasoline. Conversion costs for outgoing transfer of gasoline as given by nearly all owner/operators and contractors include a conversion to bottom loading. This conversion, also discussed in Section 6, adds significantly to the cost of installing a balance system to outgoing trucks. Costs to install a balance system between the customer tank and account truck also included the bottom loading conversion and were therefore high. Difficulties, including lack of hardware, in adapting to the variety of customer tank interfaces was also mentioned by owner/operators.

5.2.4 Secondary Systems

Secondary process units are used in conjunction with the vapor balance system for service station applications. The term "secondary" has been applied since the prime control of working losses is accomplished by the use of the balance system. The "secondary" system processes the excess from the balance system. All of these systems could conceivably be used as primary units and will be initially discussed in that manner. Of these many potential systems, some are not past the initial developmental stage for use in bulk plants.

The major differences between the secondary systems applied to bulk plants as compared to service station applications are (1) the general lack of vacuum assist requirements and (2) potential capacity differences. A vacuum assist is used in service stations to reduce the leakage at the vehicle tank fill port interface. Nozzle designs have been unable to cope with the variety of vehicle fill port interfaces without either losses or a vacuum system tending to draw air into the vapor return lines at this interface. Typical bulk plants can use leak tight couplings which obviate the need for a vacuum assist unit, unless other significant leakage is present.

Application to a bulk plant may also involve a change in capacity of the "secondary" processing unit. Breathing loss control and variation in throughput may require variation in capacity. However, some manufacturers already have several models with various capacities, thus capacity difficulties are not expected to be significant.

5.2.4.1 Adsorption

One method for reducing emission, both working and breathing from tanks and trucks is by use of an adsorbent. The adsorbent (often activated carbon) is a high surface area material to which hydrocarbons are selectively attracted. Special canisters built to expose the maximum surface area are used and may be readily exchangeable. These canisters, placed at the pressure vacuum valve vents, essentially cleanse the effluent of hydrocarbons and pass purified air to the atmosphere. Canisters must be regenerated or replaced periodically.

Application to a bulk plant was not observed. Difficulties appear to be related to sizing (must handle breathing as well as excess working losses handled in service station applications) and regeneration. The regeneration in industrial locations has involved steam-stripping the hydrocarbons from the adsorbent, condensing the steam and recovering the remaining hydrocarbons. Although other methods are available, regeneration will probably require off site processing, due to the complexity, cost involved, and lack of some utilities at a typical bulk plant. Off site regeneration difficulties include lack of availability and travel distances to widely scattered bulk plants in some areas. Application to trucks or customer tanks involve further difficulties of weight plus high costs due to multiple unit requirements.

5.2.4.2 Absorption

A similar method relies on absorption. A low vapor pressure liquid is used to absorb hydrocarbons in the vents. One possible absorber is diesel fuel which is available at most bulk plants. This system can be set up as a scrubber type device using diesel fuel from plant storage tank. Insufficient data is available for determining the effect on the diesel fuel. This method cleanses exhaust gas from the tank vents and can reduce both working and breathing losses.

Difficulties involve the use or regeneration of the diesel fuel or other absorbent. Diesel fuel cetane ratings may be adversely affected by absorbed gasoline vapors. Regeneration, if required would also probably require off site processing. Use on truck and customer tank vents would involve further potential difficulties of weight and high cost due to multiple units. Since no directly related application was located in service station or terminal locations, a better definition of bulk plant applicability would require a separate effort.

5.2.4.3 Refrigeration

Refrigeration is a method currently used at one bulk plant. In this plant, the storage tank vapors are drawn (using a blower) from the tank ullage to cooling coils. Cooled vapors are returned to the storage tank ullage, and any condensate is collected in a separate tank (see Figure 5-1). Cooling coils are supplied (cooled) by a 5.6 kilowatt (7 1/2 horsepower) refrigeration system. This system essentially maintains the vapors at a nearly constant cool temperature of 16°C. This controls breathing losses and reduces the hydrocarbon concentration of vented gases.

Other arrangements of refrigeration systems are possible. Cooling of liquid gasoline in the tank can also be accomplished but efficiency

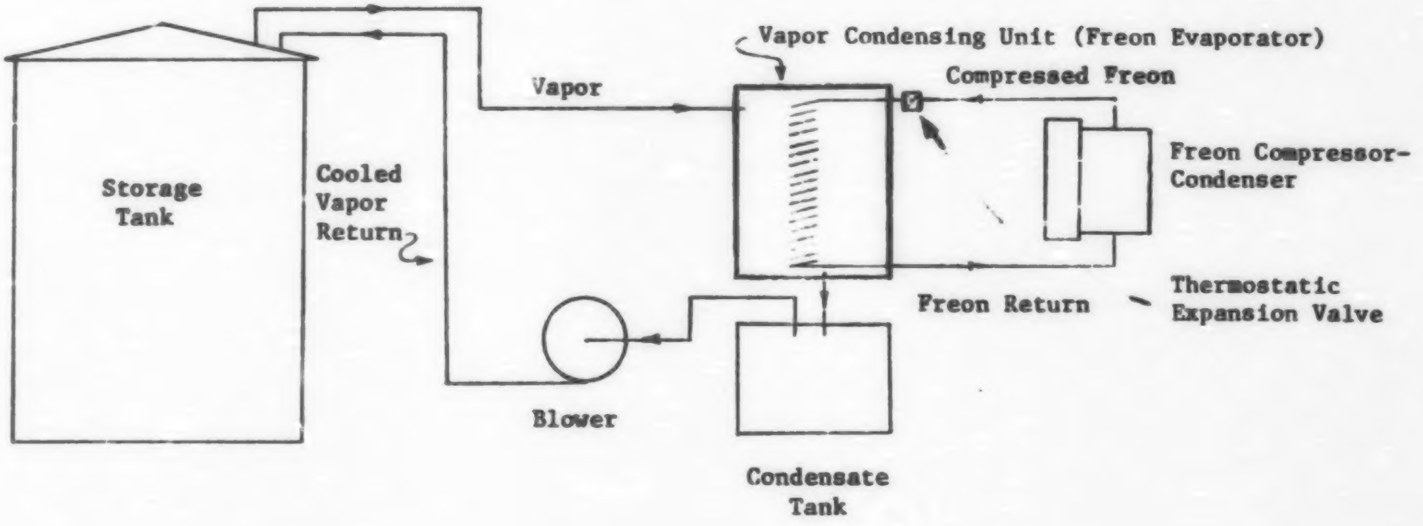
Vapor Condensing Unit (Freon Evaporator)
Compressed Freon
Vapor
Storage Tank
Cooled Vapor Return
Freon Compressor-Condenser
Thermostatic Expansion Valve
Freon Return
Blower
Condensate Tank

Figure 5-1. Refrigeration System

will probably be reduced. Efficiency loss is due to increased temperature variation in the ullage space (now only controlled indirectly by heat transfer to liquid), larger heat transfer surface area for heat inputs and natural liquid convection (cooled gasoline will circulate to the bottom of the tank).

Another possible refrigeration arrangement is to place cold coils at the outlet of the vent valve. These coils, at temperatures generally under 0°C (32°F), would essentially condense the hydrocarbon vapors prior to escaping to the atmosphere. Design difficulties include large capacity refrigeration or reservoir to handle large vent flowrate, handling ice formation, and safety (saturation concentration of hydrocarbons may pass through explosive range on cooling).

Difficulties common to all refrigeration systems include significant operating costs (electric power consumed, for example), space or weight requirements (for example, mounting on trucks) and handling of condensate. The one operating system may have had other difficulties since in several years of operation it has not collected (condensed) a measureable amount of gasoline.

5.2.4.4 Oxidation

Oxidizing hydrocarbons is another secondary system used to reduce emissions. Two methods exist; one is to use a flare stack, the other an incinerator with catalyst. Flare stacks have been used successfully in refineries but are not considered applicable to bulk plants because of the open flame. Incinerator devices have been installed in several San Diego locations, but are not operating due to several fires. These methods are used on storage tank vents but have not been applied on moving vehicles. Oxidation eliminates the hydrocarbons from the exhaust gas by converting them to carbon dioxide and water. The incinerator is normally activated during venting. Catalyst is heated to approximately 900°F whereupon oxidation of hydrocarbons occurs.

Special safety requirements include precluding uncontrolled vapor fires, preventing flash back into storage tanks (Underwriters Laboratory does not list an in-line flame arrestor), and precluding ignition of fugitive hydrocarbon emissions. Design difficulties include variable hydrocarbon concentration, catalyst poisoning, and control requirements. Although these difficulties are not insurmountable, poor operating experience to date has resulted in unfavorable attitudes of owner/operators and fire officials.

5.2.4.5 Compression - Refrigeration - Condensation

This secondary system was not observed at bulk plants, but has been used in refineries and terminals. The air-hydrocarbon mixture is essentially used as the working fluid in a refrigeration system and the condensed hydrocarbons (after cooling) are removed from the effluent prior to release to the atmosphere. The primary process steps compress the air-vapor mixture (raising temperature as well as pressure), cool the compressed mixture (generally using water and/or air) then expand the mixture (lowering temperature and pressure). The system would be placed at the tank vent, or could be used to cool ullage similar to the operating refrigeration system.

Difficulties include significant operating costs, space and weight requirements, handling of water and/or ice formation, variable efficiencies with range of potential hydrocarbon concentrations (typical design is to saturate incoming mixture to avoid difficulty), and handling of condensate. Initial costs from manufacturers were generally above $50,000.

5.2.5 Miscellaneous

Refinery processes such as cracking or reforming might be adapted to modify the molecular weight of hydrocarbon emissions and convert reactive hydrocarbons to non-reactive compounds. No application to bulk plants was found. Principal difficulties are unknown efficiencies, high energy input requirement and costs. The complexities of these processes are probably beyond the capability of a bulk plant.

Reducing the tank pressure excursions is another concept that has not been applied to bulk plants. Insulation of tanks can control breathing losses (for example, underground tanks), but amount of insulation required may be prohibitive. Application of insulation to existing tanks may also be difficult. A second concept is to transfer vapors (or liquid) to a smaller pressurized holding tank during times when storage tanks tend to increase in pressure and release vapors (or liquid) during times of pressure decay. For vapors, this could involve a compressor, pressurized holding tank, and control system. Difficulties may include safety of compressed (and high temperature) vapors, costs, and control logic complexity (expansion of vapors from holding tank will cool tank ullage).

5.2.6 Bladders

An impermeable bladder or a flexible membrane within the tanks would prevent the escape of the air-hydrocarbon mixture above the liquid gasoline surface while allowing the liquid level to rise and fall. This controls both working and breathing losses. No application to bulk plants was observed but terminal vapor holding tank and military aircraft fuel tank applications were noted.

Although conceptually, this method is simple and potentially 100% effective (if all trucks and storage tanks use bladders) unfortunately, significant difficulties are present. The cost of the bladders is high. Standard Oil Avon Terminal personnel quoted a cost of $10,000 for a vapor holding tank bladder and manufacturers indicated military aircraft bladders are also expensive primarily due to stringent specifications.

Prime difficulties are leakage and wear of the bladder. Standard Oil Avon Terminal (San Francisco Bay area), has replaced the vapor holding tank bladder several times due to leakage or tears. Manufacturers indicated that the tank interior must be specially adapted to a bladder (no sharp corners, fixed inlet openings, and restrictions on bladder movement).

Another difficulty is retrofit of the tanks. Installation of a bladder into an existing tank requires access, points of attachment and potential movement restraints. Existing tanks may not be able to accomodate a bladder, especially smaller tanks.

5.3 COMBINED CONTROL ALTERNATIVES

A cursory review of the individual control alternatives was performed in order to select candidates for combined control review. Control efficiency and development status (affects how quickly alternatives can be implemented) were the primary criteria. Costs and applicability were only considered when they bordered on infeasibility. Not one of the alternatives could control all emissions with little or no development required.

The following were considered for combined alternative comparisons: submerged fill, pressurization, balance system, and some secondary systems. Bladders and remaining secondary system concepts were ignored due primarily to development, cost and applicability factors. Table 5-2 presents a summary of the comparisons.

No inherent difficulties in combining alternatives were noted. In general, combinations increased overall efficiency and cost. Development time and applicability were generally the same as the least applicable alternative.

5.4 EVALUATION OF SELECTED CONTROL CONCEPTS

Based upon review of individual and combined control alternatives, the following concepts (alternatives) were selected for further study; submerged fill, pressurized tanks, balance system and a few secondary systems. Discussion is based on each concept even though they exist in combination with other controls. Efficiencies are discussed in detail in Section 7 or Section 4. Costs, where available, are discussed in Section 6. The following discussion emphasizes the development and applicability of each of the selected concepts.

5.4.1 Submerged Fill

Submerged filling can reduce working losses to a significant degree (see Section 4) and is easily adapted to any underground storage tank, or top-loading truck. As mentioned earlier, submerged fill is an integral feature with bottom-loading trucks and above-ground tanks. The system has no significant effect on breathing losses. Cost of conversion is extremely low and applicability to bulk plant operations is good. In top-loading facilities a nozzle extension is the only addition necessary to provide for subsurface loading of the account trucks. For underground storage tanks, a pipe is normally affixed inside so that the discharge occurs near the bottom.

Submerged filling of customer storage tanks can be accomplished with either nozzle extension or a permanently attached drop tube. Some difficulties have occured with the installation and use of permanent

Table 5-2. COMBINED CONTROL ALTERNATIVES

CONCEPT[a]	ANTICIPATED EFFICIENCY (%)							Estimated Initial Cost ($1,000)	Development Req'd.	Plant Applicability	REMARKS
	Storage Tank		Incoming Truck	Outgoing Truck		Customer Tanks					
	Breathing	Working	Breathing	Working	Breathing	Breathing	Working				
alance Systems #1 & 2	<10	>90	<10	>90	<10	--	--	<50	No	Good	Old trucks and tanks may require repair.
lance Systems #1, 2 & 3	<10	>90	<10	>90	<10	<10	>90	>50	Little	Fair-Good	Old trucks and tanks may require repair.
Balance Systems #1 & 2 plus increased pressure capability #1 or 2 or 3	<90	>90	<10	>90	<10	--	--	<50	No	Fair-Good	Old tanks may require repair or replacement.
alance System #1 & 2 plus increased pressure capability #1 or 2 or 3 & 4	<90	>90	<90	>90	<90	--	--	>50	Little	Fair	Old trucks and tanks may require repair or replacement.
Balance Systems #1, 2 & 3 plus increased pressure capability #1 or 2 or 3 & 4 & 5	<90	>90	<90	>90	<90	<90	>90	>50	Some	Fair	Old trucks and tanks may require repair or replacement.
Balance System #1 plus submerged fill #2	<10	>90	<10	<90	<10	--	--	<50	No	Good	Old tanks may require repair.
Submerged Fill #2 & 3	--	--	<10	<90	<10	<10	<90	<50	Little	Fair-Good	"Spit back" problems.
Balance Systems #1 & 2 plus submerged fills #2 & 3	<10	>90	<10	>90	<10	<10	<90	>50	Little	Fair-Good	Old tanks and trucks may require repair plus "spit back" problems.
Balance System #1, plus submerged fills #2 & 3	<10	>90	<10	<90	<10	<10	<90	<50	Little	Fair-Good	"Spit back" problems.
Balance System #1, increased pressure capability #1 or 2 or 3 & 4 & 5 and submerged fills 2 & 3	<90	>90	<90	<90	<90	<90	<90	<50	Some	Fair-Good	Old trucks and tanks may require repair or replacement plus "spit back" problems.
Balance System #1 & Adsorption #1	>90	>90	<10	--	--	--	--	<50	Some	Fair	Regeneration still required but reduced by balance system.
Balance System #1 & 2 plus Adsorption #1 & 2	>90	>90	>90	>90	>90	--	--	>50	Yes	Fair	Same as above.

Table 5-2. COMBINED CONTROL ALTERNATIVES (Continued)

CONCEPT[(a)]	ANTICIPATED EFFICIENCY (%)							Estimated Initial Cost ($1,000)	Development Req'd.	Plant Applicability	REMARKS
	Storage Tank		Incoming Truck	Outgoing Truck		Customer Tanks					
	Breathing	Working	Breathing	Working	Breathing	Breathing	Working				
Balance Systems #1, 2 & 3 plus Adsorption #1, 2 & 3	>90	>90	>90	>90	>90	>90	>90	>50	Yes	Poor-Fair	Regeneration still required but reduced by balance system.
Balance System #1 & Absorption #1	>90	>90	<10	--	--	--	--	<50	Yes	Fair-Poor	Requires use or regeneration of product after absorption.
Balance Systems #1 & 2 plus Adsorption #1 & 2	>90	>90	<90	>90	>90	--	--	>50	Yes	Poor-Fair	Same as above.
Balance Systems #1, 2 & 3 plus Absorption #1, 2 & 3	>90	>90	<90	>90	>90	>90	>90	>50	Yes	Poor	Same as above.
Balance System #1 & Refrigeration #1	>90	>90	<10	--	--	--	--	>50	Some	Fair-Good	Operating cost significant.
Balance System #1 & Refrigeration #2	>90	>90	<10	--	--	--	--	>50	Yes	Fair-Good	Operating cost reduced by balance system.
Balance Systems #1 & 2 plus Refrigerations #1 & 3	>90	>90	>90	>90	>90	--	--	>50	Yes	Fair	Operating cost very significant.
Balance Systems #1 & 2 plus Refrigerations #2 & 4	>90	>90	>90	>90	>90	--	--	>50	Yes	Fair	Operating cost reduced by balance system.
Balance Systems #1, 2 & 3 plus Refrigerations #1, 3 & 5	>90	>90	>90	>90	>90	>90	>90	>50	Yes	Poor	Operating cost prohibitive.
Balance Systems #1, 2 & 3 plus Refrigeration #2, 4 & 6	>90	>90	>90	>90	>90	>90	>90	>50	Yes	Fair-Poor	Operating cost reduced by balance system.
Balance System #1 & Oxidation #2	>90	>90	<10	--	--	--	--	<50	Some	Poor-Fair	Safety and maintenance drawback.
Balance System #1 & CRC	>90	>90	<10	--	--	--	--	>50	Some	Fair	Maintenance & operating cost drawbacks.

DEFINITIONS:

Development Terms No = Presently applied to bulk plants with few problems; Little = Presently applied to prototype bulk plants or directly related application with few problems; Some = Presently applied to prototype or related Petroleum Marketing application; Yes = No known present application or problems associated with application.

Applicability Terms Good = No technical problems expected; Fair = Some repair or replacement of equipment may be required; Poor = Major installation or maintenance beyond the capability of typical plant.

-- Not applicable

NOTE: (a) Numbers refer to systems defined in Table 5-1.

drop tubes. One problem is "spit back." "Spit back" is the return flow and spillage of gasoline at the fill port during transfer. This appears to be primarily related to the smaller fill port and drop tube sizes in customer tanks, compared to service station tanks, and the lack of a coupling at the fill port interface. Use of a nozzle extension with or without a permanently installed drop tube or a coupling should solve the "spit back" problem.

Another difficulty with the use of submerged filling with customer tanks is the variety of fill ports. Fill ports vary in diameter, type and accessibility. The problem can be likened to the variety of vehicle fuel tank interfaces. The total costs to adapt to this number and variety of customer tank interfaces may be significant. In addition, operators indicate submerged fill hardware is not available for some configurations.

One question which arises is the actual usage of submerged fill when the system is installed. For instance, if a top loading rack or "drop tube" can not be permanently attached, due to inadequate truck clearance, the driver has little incentive to attach the drop tube prior to each filling of the account truck. Similarily a driver may not bother using a variety of detachable "stingers" during customer tank filling.

This non-use of submerged fill can be reduced by several means. Requiring a permanently installed submerged fill tube may be feasible for many tanks. "Spit back" will further encourage the use of a nozzle extension or coupling. Permanent extension on loading rack could be flexible or telescoping in order to achieve adequate truck clearance.

Another method would be to require a "dry break" at each disconnect point. This would reduce spillage and prevent flow without complete assembly. Other enforcement techniques, such as fines, inspections, training programs are also available.

5.4.2 Pressurized Tanks

Breathing losses can be controlled and working losses slightly reduced by increasing the operating pressure range of the tanks. Efficiency is discussed in Section 4. Costs are generally low for small pressure changes of this type if rework or replacement of tanks is not required.

Applicability is a difficult area. Vessels with operating pressures under 103,000 newtons/square meter (15 psi) are exempted from specific requirements (Reference 5-b,c) but Reference 5-c states that "good engineering practices" or "recognized standards" are required for all pressure vessels. Reference 5-d indicates that only nonexempt tanks would be subject to inspection. Procedure, per Reference 5-d, for allowing an increase in operating pressure range for nonexempt tanks would be to verify that the new operating pressure did not exceed the operating pressure certified by the manufacturer. If this certification was not available (most bulk plant operators questioned did not know even the name of the storage tank manufacturer, let alone the certified operating pressure) detailed engineering data, including a new proof test, would be required.

Although "good engineering judgement" for exempt tanks may not require the above mentioned procedure, a certain amount of verification that the tanks will be able to operate safely at increased pressures seems wise under the conditions of a typical bulk plant. These conditions are age (average of 36 years old), uncertain maintenance, susceptibility to rust and corrosion, and storage of a flammable substance. In addition, Reference 3-g indicates that some bulk plant storage tanks are not salvaged (transferred to other locations) during disposal of excess bulk plants due to the poor condition of the tanks.

Problems associated with increasing the tank truck operating pressure range are not quite as difficult to define. Trucks are generally newer and maximum operating pressure can be specified, generally in the order of 6,900 newtons/square meter (1 psi). However, the set points of the pressure vacuum valve must account for variability of the valve, pressure drop across open valve at full flow and the incremental pressure required to fully open the valve. "Good engineering judgement" of the San Diego Air Pollution Control District is to leak-test at (approximate the minimum relief opening pressure) 5,500 newtons/square meter (22 inches of water or .9 psi) while the "good engineering judgement" of the Truck Trailer Manufacturers Association (Reference 5-e) is to leak-test at 3,200 newtons/square meter (13 inches of water or .6 psi). Several truck contractors have indicated difficulty in consistently achieving leak-tight cargo compartments when required to apply the higher pressures specified by San Diego.

Customer tanks were not investigated. However, the difficulties associated with bulk plant storage tanks would seem to apply to customer tanks. In addition, the variety of tank types and sizes indicates even further difficulties in defining a minimum operating pressure range.

5.4.3 Balance System

Balance systems were observed in use at many bulk plants. The efficiency of a balance system is fully discussed in Section 7. Efficiency is good for the control of working losses but not significant for the control of breathing losses. Section 6 reviews the available cost data for balance systems. The initial facility costs are in the order of $4,000 for incoming transfer of gasoline but significantly more costly for outgoing transfer of gasoline.

The majority of balance system installations noted were between the incoming loads and the plant storage tanks. Incoming trucks were generally equipped for vapor recovery because of service station regulations. Typical facility modifications involved adding aboveground piping from the incoming truck unloading area to a manifold which interconnects each gasoline storage tank. The presence of a manifold is different from service station applications. Common manifold is acceptable since only a single grade of gasoline is normally delivered at one time at bulk plants. Service stations, especially when dispensing, may involve the simultaneous transfer of several grades of gasoline.

The vapor return line entry into the storage tank may require (1) attachment of a metal plate which can be drilled and tapped or welded on to, (2) drilling and tapping or welding onto an existing appendage, (3) using an existing port, or (4) teeing off an existing vent line piping. The older the tank, the less likely an existing port or vent line will be available for use. Older riveted tank material may not be easily weldable.

The most common problem noted was leakage. Old tank hatches, valves, seals, manholes and sealing surfaces may require significant repair or replacement to affect a seal. In addition, even if only a replacement component is required, the lack of spare parts for discontinued models may require special orders further increasing costs. If costs to an individual bulk plant owner begin approaching the high end of the range of costs for this modification ($18,000), owner may investigate replacement and possible relocation of storage tanks underground.

Installation of a balance system to the loading rack to return vapors from the account truck to the storage tank presents a more complex picture. Nearly all owner/operators, contractors and major oil companies contacted included a conversion of the loading rack from top loading to bottom loading in the total modification to achieve a vapor recovery balance system. A discussion of top and bottom loading facilities is discussed in Section 5.5.

The application of a balance system to the transfer of gasoline to the customer tanks was not common in the surveyed areas. However, except for accessibility and hardware variety/availability difficulties previously reviewed in connection with submerged fill systems, no other difficulties were mentioned by drivers or operators. When customers cannot afford the costs of modifications required to meet vapor recovery regulations, bulk plant operators will sometimes bear some part of the cost in order to retain the accounts.

5.4.4. Secondary Systems in Conjunction with Balance System

The most promising secondary systems appear to be refrigeration and adsorption. Both are somewhat developed, can potentially be applied to trucks and/or customer tanks, and are capable of controlling emissions due to breathing and working losses. Disadvantages include cost and development time.

Other secondary systems suffer from safety problems (oxidation), system complexity (compression--refrigeration--condensation), or required development (absorption). All secondary system evaluations must be considered as based on engineering judgment since only one operating bulk plant was observed with a simple secondary system.

5.4.4.1 Adsorption

Adsorption systems have excellent potential for controlling both working and breathing losses. This is based upon industrial solvent recovery and service station applications. Canisters with hydrocarbon adsorbents would be attached directly to the vent lines of storage tanks. Some development of the system is required especially for trucks and customer tanks. Maintenance of the system is of primary concern since canisters will need to be changed from time to time for regeneration. Questions which require resolution are: who or what will regenerate the canisters, at what cost, and is it practical to do so? Answers to these questions will probably be strongly dependent upon service station use of adsorption systems.

Enforcement may be another, related concern. How to insure the efficiency (regeneration) of these canisters may require significant enforcement activity, especially if trucks and customer tanks are included.

5.4.4.2 Refrigeration

The only operating secondary system observed during the survey was a refrigeration system. This system only controls breathing losses, but when used in conjunction with a balance system, gives control of both breathing and working losses.

Operational history at the bulk plant has been fair. The compressor and electrical systems have required frequent repair and/or replacement. The refrigeration system can be viewed as a large air conditioning unit similar in size to a central air conditioning unit. The inherent maintenance difficulties should therefore not be as large as the operational history suggest. Factors at this bulk plant which may influence these difficulties include: (1) bulk plant unit is exposed to the elements, (2) skid mounting may not adequately damp vibrations (3) unit is not mass produced and (4) long refrigerant lines resulting from remote location give increased chance of refrigerant leakage. None of these factors appears insurmountable given the success in applying air conditioning systems to other industries.

The other potential problems, such as safety and condensation of water, appear to be minimal. However, no significant amount of gasoline has been recovered by the one existing operational system. This lack of recovery may be due to (1) leakage, (2) re-evaporation of gasoline in the condensate tank during transfer to incoming tank trucks and/or (3) re-evaporation to storage tanks. These reasons are either harmless (re-evaporation) or not insurmountable (leakage).

Application of a regrigeration system to account trucks requires development, but success with both mechanically and liquid nitrogen refrigerated trucks indicates a high probability of success. Customer tank application difficulties are primarily related to cost.

5.5 BOTTOM LOADING CONVERSION

In modifying bulk-plant equipment to implement vapor recovery by the vapor-balance system, it is customary to convert loading racks and trucks to a bottom-loading system, if they are not already designed for it. Although this is done partly to facilitate vapor recovery, other advantages are often cited, such as (1) improved safety, (2) reduced labor cost, (3) versatility and (4) potential increases in delivery rates.

Relative to vapor recovery, the primary advantage in bottom-loading appears to be ease of integration with supplier and customer vapor recovery systems. Account trucks are sometimes used to deliver directly from the supply terminal or refinery. If the supply point is required to recover vapors, the account truck must interface with the vapor return lines. Reference 5-f indicates a strong industry trend to recover vapors and to load using bottom loading at terminals. A nationwide survey (Reference 5-f) indicates approximately 20% of all major oil company terminals used bottom loading at the end of 1974 and another 6% were scheduled for conversion in 1975. Thus, if a bulk plant operator wished to continue to be able to deliver direct from a terminal converted to bottom loading requiring vapor recovery, the operator must convert his account trucks.

Regulations also require recovery of vapors at some customer tanks, for example, service stations. An account ruck converted to bottom loading with vapor recovery needs no further modification to recover vapors from the customer tanks, except for possible fill port adaptors. Converting a top loading rack to recover vapors at the bulk plant accomplishes nothing with respect to recovering vapors from customer tanks. The manifolding and vapor return plumbing required on account trucks to recover vapors from customer tanks is essentially identical to the vapor return plumbing present for bottom loading vapor recovery. Thus, a portion (vapor return) of bottom loading truck conversion is required to recover vapors from customer tanks.

It has also been argued that bottom-loading systems allow more efficient vapor recovery. Top loading, even with a submerged fill tube, generates vapor entrainment and turbulence (splash loading) for a portion of the gasoline transfer time. A submerged fill tube may be as much as 15 cm (6 inches) from the tank bottom whereas bottom loading outlet, by definition, is always submerged when any gasoline is in the tank truck. In addition, even after the drop tube is submerged, typical sharp edged outlet configuration (cut off section of pipe) may generate more turbulence than typical smooth transition bottom loading configuration. This turbulence may lead to additional evaporation which increases pressure and decreases the efficiency of a balance system. Although the argument is sound, the effect may be unimportant.

As discussed below, it is technically feasible to apply vapor recovery systems to top-loading equipment. However, it has been argued that the cost of such systems may be excessive in view of the other advantages of conversion to bottom-loading. (See Section 6 for discussion of costs). In any event, it is striking that none of the plants surveyed in this study had vapor recovery systems associated with top-loading equipment.

Top-loading vapor recovery systems have existed for some time at terminals (Reference 5-g). A large diameter elastomeric seal, similar to a bottle stopper, is incorporated around the top-loading arm, vapor return line, and truck hatch interface. This seal is held in place with actuators (typically a pneumatically actuated piston with a closed cylinder). The difficulties associated with applying this system to an existing top loading rack at small bulk plants are (1) loading arm will probably require stiffening to take the added weight of vapor return hardware, actuator forces and sealing loads, (2) lack of compressed air source at typical bulk plant, (3) additional structure may be required to counteract actuator forces, (4) added weight may require additional counterbalancing or other actuators for normal operation, (5) actuator(s) may require explosion proof electrical control box(es) at the end of the loading arm, and (6) this type of vapor recovery hardware may no longer be available (for example, EMCO Wheaton has discontinued top-loading vapor recovery model E293).

However, a second type of top loading vapor recovery equipment must be considered. This type replaces the large elastomeric seal with a coupling, which has been used for aircraft refueling, between the tank hatch and loading arm/vapor return fitting. One contractor (J-8 Equipment) proposed using this type of equipment on a bulk plant in Boulder, Colorado. Primary advantage is the elimination of an actuator to effect a seal. Thus, at least for one bulk plant, many of the difficulties previously mentioned may be eliminated. However, an actual bulk plant installation was not located. The extent of typical top loading rack modifications required (such as stiffening and counterweights) is not well defined. In addition, special truck modifications may be required for this type of top-loading vapor recovery (installation of mating connector on truck). Impact of this modification on hatch closure and rollover protection is also not well defined.

Top loading vapor recovery and bottom loading vapor recovery have some common costs. Because liquid level in the truck tank is no longer visible in either loading method with vapor recovery, truck overfill protection is required to preclude damage to lines not designed to handle liquid and contamination of no-lead gasoline. This can be in the form of an electrical float switch at the top of the truck cargo compartment which, when actuated, shuts off the pump. This switch arrangement requires rewiring of pump controls, and explosion proof electrical connections and switches.

Another type of overfill protection is a float valve at the cargo tank vapor return port. As the liquid level rises, float seals the port precluding liquid gasoline from entering vapor lines. Primary disadvantage is that pressure will now increase in the cargo compartment unless the driver shuts off the pump. This is somewhat alleviated by a bleed hole to the vapor return lines typically present in float valve hardware (OPW 53-V, for example). If driver does not turn off pump by the time the liquid level reaches the bleed hole, pressure will increase in the cargo tank as well as liquid gasoline damaging and/or contaminating the vapor return lines.

Further methods taken to prevent overfill include (1) replacement of old meters with preset delivery meters, (2) dead man switches, and (3) sight flow indicators. Preset delivery meters will only deliver a preset amount of gasoline unless reset. Thus, if amount present is less than remaining capacity in cargo tank, chance of overfill is eliminated. "Dead man" switches require continuous manual depression of an electrical (explosion proof) switch for pump to operate. The theory is that driver, being present, will shut off pump at the first indication of overfill. Sight flow indicators are transparent sections in the liquid lines, sometimes fitted with paddle wheels or swirl devices, allowing the driver to see changes in flowrate, for example, when the float valve closes.

Other potentially similar costs for bottom-loading or top-loading vapor recovery at the loading racks involve replacement of liquid transfer components. The vapor balance system adds an incremental pressure to the amount that must be overcome by the liquid pump. This incremental pressure is required to drive the truck cargo compartment vapors through the vapor return lines up to the storage tank ullage space. Although the amount of this pressure drop is generally low, the effects may be significant. One large operator estimated a 15% flowrate reduction when vapor recovery was added to a bottom-loading rack. Since draining tank ullage would tend to be at a slightly negative pressure, the liquid net positive suction head required for the liquid pump to operate may be approached. These difficulties may require new pumps and/or larger liquid lines.

In summary, a comparison between top-loading vapor recovery and bottom-loading conversion included in vapor recovery systems appear to be clouded with uncertainties. There are undoubtedly valid reasons to include a portion of bottom-loading conversion costs in the modification for vapor recovery. The complete lack of top-loading vapor recovery installations and 100% bottom-loading conversions when bulk plants have been required to recover vapors in the surveyed areas confirms this conclusion. However, the fact that other reasons to convert to bottom-loading exist makes it difficult to determine the significance of each factor in the decision to convert to bottom-loading and the portion of the total cost ascribable to vapor control regulations.

5.6 SAFETY AND OTHER GENERAL CONSIDERATIONS

As a general rule, the more complex a vapor recovery system is, the higher the risk of an accident. Accidents involving gasoline and gasoline vapors can be very serious, therefore the risk of an accident must be kept very low. Although all secondary systems can be made safe (using redundant components, for example), early actual service station and bulk plant safety and reliability experience was poor. This conclusion was expressed by California and Colorado fire prevention personnel, Capt. T.W. McDonald and Capt. D. Kennerson. Fires and equipment failures have shut down all bulk plant secondary systems in San Diego except the one previously mentioned.

Equipment design flaws, lack of complete certification by Underwriter Laboratories (or equivalent), vulnerability of vapor lines and equipment to physical damage, observed installation errors, high incidence of fire in locations with vapor recovery equipment, and ease of operator's error causing serious hazards were the major causes of concern. Both fire captains, however, concluded that the systems, if given time and effort for certification, testing, code revisions, and experience were capable of acceptable safety.

Safety concerns become even more significant for truck or customer tank secondary systems. Although no applicable data was found, security of these systems from physical damage and adequate maintenance must be accounted for. Further effort will be required to adequately evaluate and balance the risks against the reduction in emissions.

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5-c State of California, Title 8 Industrial Relations Division of Industrial Safety, Chapter 4, Subchapter 1, Unfired Pressure Vessel Safety Orders.

5-d Discussion with Mr. Brandt, Los Angeles Department of Building and Safety.

5-e TTMA Recommended Practice, "Leak Testing of Cargo Tank Vapor Recovery Systems," RP NO. 50-76 dated May 28, 1976, Truck Trailer Manufacturers Association.

5-f 1975 National Petroleum News "Factbook Issue," mid-May 1975, McGraw Hill.

5-g AP-40, "Air Pollution Engineering Manual," 2nd Edition, Environmental Protection Agency, 1973.

6. DIRECT COSTS OF EMISSION CONTROL SYSTEMS

Initial costs of hydrocarbon control systems are reviewed in the sequential order in which gasoline is received and then transferred from bulk plants: (1) incoming transfer, (2) storage, and (3) outgoing transfer. Other costs and scaling factors are then discussed.

6.1 INCOMING TRANSFER CONTROL COSTS

6.1.1 Modification of Incoming Transports

Costs associated with the modification of incoming transports are not considered a part of bulk plant costs but information was obtained and is shown in Table 6-1. Incoming transports are not normally operated by the bulk plant operator but by the major oil company or commercial carriers. Two independent commercial carriers contacted indicated that only 5-10% of their total deliveries go to bulk plants, and that vapor recovery requirements for the other deliveries would specify modification requirements for their truck-trailers.

6.1.2 Submerged Fill

Application of the submerged-fill technique does not require modifying above-ground storage tanks. Underground tanks require a "drop tube" with the discharge opening not more than 15 cm (6 inches) from the tank bottom. A typical hardware cost (i.e., submerged filling tube, OPW 61-T) is $25 and installation is generally simple for tanks utilized at bulk plants.

Submerged-fill modifications thus add very little to the overall emission control costs.

6.1.3 Balance System

This system is the most common method of emission control. Table 6-2 summarizes the initial cost data obtained for underground and above-

Table 6-1

INITIAL COST OF VAPOR BALANCE SYSTEM FOR INCOMING TRUCKS

SOURCE OF DATA	Number	Cost ($1,000)		
		Low	Ave.	High
Plant Operators	10	3.5	5.1	6.7
Contractor				
With Bottom Loading	7	0.6	5.1	10.0
Without Bottom Loading	5	0.6	2.6	6.0
Representative (1)	6	0.6	4.8	10.0

(1) Only multi-installation sources used for data.

Table 6-2
INITIAL COST OF VAPOR BALANCE SYSTEM AT BULK PLANT FOR INCOMING LOADS

SOURCE OF DATA	Number	Cost ($1,000)		
		Low	Ave.	High
Plant Operator				
Total	64	0.65	3.0	9.1
Contractor Installed	41	0.65	3.9	9.1
Operator Installed	23	0.15	1.3	6.0
Underground Tanks	41	0.15	3.2	9.1
Above-Ground Tanks	21	0.5	2.0	8.0
Both Types	2	1.5	2.8	4.0
Major Oil Company (1)				
Total	14	0.6	5.0	8.6
Contractor				
Underground Tanks	6	0.2	0.8	1.8
Above-Ground Tanks	12	0.8	4.4	18.0
Representative (2)	8	0.8	4.2	18.0

(1) Includes specific plant and average data.

(2) Only multi-installation sources used for data.

NOTE: Costs include data from completed and planned installations.

ground storage. Initial cost includes hardware and installation. Typical hardware for above-ground tanks includes piping, fittings, supports, pressure-vacuum (PV) valves, liquid traps, paint, disconnects, seals and gaskets. Typical installation work includes draining the tank, assembling piping and supports, breaking into existing tank top or vent, painting, leak testing, replacing PV valve, replacing seals and occasionally repairing leaks by welding tanks or covers. One contractor estimated one out of three tanks (one per plant on average) required welding. Miscellaneous costs include permit fees, inspection, insurance, temporary barricades and cleanup. Costs listed do not include facility down-time, contract negotiation time, design and drafting, and time to obtain financing.

If underground tanks require only a coaxial fitting such as Emco Wheaton F-298, a typical installed cost is $600. A small diameter fill port, side fill, PV vent requirements, leaks, concrete work and overfill protection can raise the cost significantly. However, the cost of installing a balance system on an underground tank is generally lower than the installation on an above-ground tank.

In 36% of the cases studied, the operators performed the installations. Although some direct labor costs were included in the estimate, costs generally represent only hardware costs. These installation costs will not be included in the average cost of a control system for incoming loads because of: (1) general lack of associated labor costs, (2) discrimination against those not able to install by themselves.

If a typical bulk plant (above-ground storage tanks) is used as a base, the average and range of costs derived from major oil companies, contractors and operators is fairly consistent with the average cost ranging from $3,900 to $5,000 per bulk plant. The overall range was $600 to $18,000 with only one value over $9,100 (Table 6-2).

6.1.4 Secondary Systems

No secondary system solely for control of emissions during incoming transfer of gasoline was observed at bulk plants. Cost data for secondary systems is included in Section 6.2.5.

6.2 STORAGE LOSS CONTROL COSTS

6.2.1 Underground Tanks

Although in no case were underground tanks specified solely for the purpose of reducing breathing losses, they do accomplish this purpose by maintaining a relatively constant temperature. The purchase price for each underground tank is in the order of $3,000 (Perkins Welding). The overall cost of underground tanks depends upon number of tanks, earthwork, concrete work and plumbing required. A number of plants have relocated tanks underground at the same time vapor recovery was installed at a cost of $20,000 to $40,000 depending on the number of tanks. Compliance with local ordinances requiring underground storage does not appear to be related to compliance with vapor recovery requirements.

6.2.2 Increasing the Set Point of Storage Tank Pressure-Vacuum (PV) Valve

The price of PV valves (OPW 95-UT, for example) is typically a few hundred dollars; installation is relatively simple. The total cost of implementing this system, however, depends upon other testing and potential modifications required on the storage tanks. These include non-destructive, proof and leak testing, manual venting capability, seals, gaskets and welding required, grounding, instrumentation and pump changes. Costs can be expected to vary widely. If small increases in pressure are required, other costs can be expected to be small. However, since a pressure of 10,000 Newtons/square meter (1.5 psi) gauge is required to reduce breathing losses by approximately 90% (Figure 4-1), a significant number of operators would probably convert to underground tanks if breathing loss control was required.

6.2.3 Shading

Construction of a roof will reduce the solar heating thus reducing, but not eliminating, breathing losses. Costs have not been identified, but are expected to be small.

6.2.4 Refrigeration

Maintaining a constant temperature of the storage tank contents will eliminate breathing losses. Only one plant utilized this concept and this is an experimental installation. Actual cost was in the order of $50,000 (Reference 6-a). The cost for a typical installation should be significantly reduced if an off-the-shelf refrigeration unit and other equipment can be used. Costs should approximate service station secondary system costs which are given below. Operating costs for the one operating unit were estimated at $40 per month. Maintenace costs to date have been in the order of $1,000 per year. However, this unit is a prototype unit and has undergone several modifications. The maintenance costs should be reduced significantly, as experience increases.

6.2.5 Other Secondary Processing

Oxidation, compression - refrigeration - condensation and adsorption units are available. These systems have not been installed on bulk plants in the surveyed areas except in San Diego, but are installed on some service stations and terminals. Reference 6-b indicates service station initial costs for a total system including vapor balance and secondary processing of $11,500. Costs for terminals are much larger (for example, Ameron's smallest unit cost was $70-$75,000) because they handle larger flowrates. Cost for a service station balance system along (with 6 pumps) was in the order of $5,500 (Reference 6-b). The difference of $6,000 in cost is ascribed to the secondary processing unit and is consistent with costs of $5,000 to $6,000 for the unit in San Diego bulk plants. In addition, processing units in bulk plants were the same as service station units with slight modifications, such as deletion of blower.

6.3 OUTGOING TRANSFER CONTROL COSTS

6.3.1 Submerged Fill

A typical bulk plant with top-loading capability requires only a drop tube to obtain submerged fill. Initial costs are thus minor (cost of short length of hose or pipe and coupling). Operating costs depend upon whether or not the drop tube is permanently attached to the loading arm. If the attached drop tube will not clear an account truck, it must be assembled and dismantled for each loading. However, this added labor cost appears to be minor.

6.3.2 Balance System

The great majority of respondents indicated that if vapor balance systems were required for outgoing transfers, account trucks would be converted from top-loading to bottom-loading. This conversion generally requires a complete replacement of the loading rack (buried piping, meters, fittings, pumps, electrical controls, and interlocks) at the bulk plant.

Estimated installation costs for complete vapor-balance and bottom-loading systems for incoming and outgoing loads range from $4,500 to $85,000 (Table 6-3). Average costs from the several sources are $33,000 to $45,000 dollars.

The costs for vapor recovery do not appear to correlate strongly with plant throughput or size, but certain factors have become apparent. Age of the facility generally increases modification costs. Tanks would normally be above ground for older plants and require longer vapor transfer lines. These older tanks may also require

Table 6-3

INITIAL COST OF VAPOR BALANCE SYSTEM AT BULK PLANTS FOR BOTH INCOMING AND OUTGOING LOADS

SOURCE OF DATA	Number	Cost ($1,000)		
		Low	Avg.	High
Plant Operator				
Bottom Loading	21	6.4	34.4	85.0
Top Loading	1	- -	6.4	- -
Major Oil Companies(1)	7	21.0	44.8	55.0
Contractor				
Bottom Loading	4	4.5	33.5	85.0
Top Loading	2	6.0	9.0	11.5
Representative(2)	1	- -	33.0	- -

(1) Includes specific plant and average data.

(2) Multi-installation source, includes conversion to bottom loading.

NOTE: Costs include data from completed and planned installations.

sealing of leaks to permit installation of pipes and fittings required for vapor conservation systems. More modification and modernization would probably also be required at the truck loading and unloading racks, leading to higher costs for old bulk plants.

The most costly plant modification necessary for vapor recovery from outgoing transfer systems is the conversion of loading racks to bottom-loading for outgoing trucks. Integration with customer and supplier vapor recovery requirements, improved vapor recovery efficiency and safety are reasons given for this bottom-loading capability. Also one manufacturer has stopped production of vapor-recovery equipment for top-loading installations. The apparent cost of this plant modification is upwards of $20,000, which includes renovation of the loading rack. One low-cost conversion (at $4,500) was accomplished at a relatively modern (approximately 8 years old) facility where the top-loading rack was modified by attachment of an extension hose.

Estimates of initial costs for contractor installations at the plant are somewhat higher for the major oil companies as compared to the jobbers. This higher cost for the major oil companies appears to be the result of installing systems with more controls and versatility than those put in by jobbers, the hiring of larger contractors to install systems in all plants within a given region and possible payment of travel per diem as the contractor moves from plant to plant. The smaller jobbers also tend to do by themselves what they can do to decrease costs. This may include digging, plumbing, and other necessary labor.

6.3.3 Account Trucks

Typical delivery trucks, "bobtails," can be retrofitted with vapor return and bottom-loading capability within a cost range of $600 to $9,900 (Table 6-4) with an overall average cost of about $4,200.

Table 6-4

INITIAL COST OF VAPOR BALANCE SYSTEM FOR OUTGOING ACCOUNT TRUCKS

SOURCE OF DATA	Number	Cost ($1,000)		
		Low	Avg.	High
Plant Operator Total	36	1.2	4.4	9.9
Without Bottom Loading	22	1.2	3.9	7.0
Major Oil Companies	2	2.5	3.8	7.0
Contractor With Bottom Loading	6	0.6	4.7	7.5
Without Bottom Loading	5	0.6	2.6	6.0
Representative(1)	5	0.6	4.3	7.5

(1) Only multi-installation sources used for data.

This wide cost range for the modification of an account truck is due to several factors; (1) number of compartments (2 to 6) per truck, with an average cost of $1,000 to $1,200 per compartment, (2) age of truck, since substantial modifications may be required for old trucks, (3) accessibility of hatch (roll protection devices) may make installation difficult, and (4) tanks of aluminum may be more difficult to work with than tanks made of steel.

6.4 MISCELLANEOUS COSTS

6.4.1 Operating and Maintenance Costs

Only a few bulk plant operators have had long-term experience with vapor recovery systems. Thus, cost information is limited. Maintenance costs for vapor balance and bottom-loading are generally expected to be small. Transfer hoses and mating fittings will require replacement. Installation of automatic controls for loading and unloading of gasoline may impose additional maintenance requirements. No direct information on operating costs was available. However, nearly half of the bulk plant operators who have had their equipment modified have indicated an increase in time required to transfer gasoline. This estimated increase in time ranged from 20% to 100%. Some operators (less than 20%) reported a decrease in time required to transfer gasoline due to upgrading of the transfer platform, pumping station and pipe line sizes.

6.4.2 Indirect Costs

Any increase in facility value should increase assessments thereby increasing taxes proportionately (Ref. 6-c). Amount will vary with tax rate.

Possible increases in insurance rates due to vapor balancing have not been resolved. To date, insurance companies have not indicated a change in rate due to any change in risk category. But an individual operator was directed to cease operation of a secondary unit due to fire risk (Ref. 6-d). One company quoted a rate of 60¢ per $100 valuation (Ref. 6-e).

6.4.3 Estimated Costs for an Individual Operator

Based upon experience with balance systems in service stations, one major oil company estimated the annual costs of a balance system in a bulk plant to be apportioned as follows:

	percent of initial system cost
interest (8 years at 10%)	6.2
depreciation	12.5
property taxes	2.5
maintenance	3.0
	24.2

A California operator, with sales of 5.7×10^6 liters (1.5×10^6 gallons per year), estimated his costs were 15% of gross. Installing a vapor balance system on his facility will initially cost $45,000. If annual cost of this system is approximately one-fourth the initial costs, his total expenses will increase to 16.5% of gross.

Although information miscellaneous costs is limited, it appears that; (1) miscellaneous costs for vapor recovery may be significant and (2) the primary impact is directly related to the initial cost.

6.5 SCALING FACTORS

Estimated plants costs for vapor recovery by use of the balance system have been found to be only slightly dependent upon throughput. Plants with 30,000 liters (8,000 gal per day) or less throughput of gasoline estimated an average $33,000 for a total balance system with bottom loading while those with throughputs of over 30,000 liters/day estimated an average cost of $40,000. This difference, however, was not significant at the 0.10 level of significance because of the large variability and small sample size (19 data points with both cost and throughput). The relative independence of costs as related to throughput seems reasonable since the gasoline handling facilities of bulk plants are quite independent of throughput. Tank capacities do not depend significantly on throughput and the numbers of tanks at a plant are a function of different grades of gasoline handled. Throughputs are increased by more frequent transfers from the storage tanks.

Thus, basic plant installation costs for a vapor balance system should be similar for each bulk plant with additional costs for each account truck owned and operated by the bulk plant and for minor items such as extra piping, manifolds, etc.

No useful scaling factor for determining plant costs for installation of a vapor recovery system as a function of size and throughput was found. Significant differences in costs seem to arise primarily due to age, condition and type of facility at the bulk plant.

Operation and maintenace costs were not defined clearly at this time but appear to be proportional to initial cost. Since vapor balance and bottom-loading are utilized only during gasoline transfer and potential damage and wear of equipment occur only during use, there may be some correlation with throughput.

Another factor which may tend to raise the quoted cost is planned vs completed installation. If survey data from operator outgoing cost estimates only from completed installations are used, the resulting average cost is approximately $33,000 vs $34,400 for overall average. Again, the large range and variability of the data does not permit the conclusion that this difference is statistically significant at a high level of confidence. However, a difference appears to be expectable since (1) estimates for planned modifications may not be minimum bids and (2) completed installations may have included some amount of self installation labor not included in quotes.

Another factor is a learning curve. Data from San Diego County, California, averaged approximately $27,000. When combined with the fact that these costs generally included a secondary processing unit (typically, 5-6 thousand dollars), this difference is statistically significant even with the small sample size (8). The difference may be explained by a learning curve, since contractors in San Diego have installed many similar systems on service stations as well as bulk plants.

6.6 COST SUMMARY

Typical costs for installation of a vapor balance system to control vapor losses due to transfer of incoming loads are $4,200 for bulk plants with above-ground tanks as compared to $1,200 for those with underground tanks. Costs on above-ground tanks would normally be higher because these tanks in addition to requiring longer transfer lines are generally older and may require sealing of leaks and modification to the structure to permit installation of pipes and hardware.

Initial facility costs to control vapor losses from both incoming and outgoing transfers are not clear. All installations completed and nearly all planned installations quoted included the cost of converting a top loading rack to a bottom loading rack with vapor return. Although a portion of these conversion costs are probably applicable, the amount is not clear.

Assumption will be made that vapor control costs includes bottom loading conversion costs. This assumption is based on (1) vapor line portion of work is directly applicable (2) some portion of modification work to liquid lines is directly applicable, such as overfill protection, and sealing the interface and (3) the few top loading vapor recovery costs derived during the survey may not be typical.

Another uncertainty is the large range of costs quoted. Some factors contributing to this variability were determined (such as age) but a complete identification of all factors was not accomplished. Larger quoted costs may have included items which would have required replacement, if vapor control modifications were not accomplished. This conclusion is based on (1) apparent dependence of cost upon age of the plant, (2) a few claims that the purchase of a new facility was caused by vapor control regulations (this information was not included in survey data base) and (3) purchase by some operators of new account trucks with vapor recovery rather than modifications to existing trucks (also not included in survey data base). Assumption will be made that quoted total costs were valid since detailed cost breakdowns were not made available.

Another area of uncertainty is the learning curve. Costs in San Diego County, California, were significantly less than other areas. However, a significant portion of plants went out of business, perhaps because their costs to comply were high. Assumption will be made that learning curve factor (San Diego data) will be applicable. This is based on (1) cost data from firms no longer in business was included in average when obtained, (2) a decrease in costs due to learning is common to other industries, (3) survey data tends to emphasize large plants (see Figure 3-2), major oil company conversions, and planned versus completed installations all of which tend to develop higher cost figures.

With these assumptions, initial balance system facility costs to control loss from both incoming and outgoing transfers will be estimated as in the order of $20,000. This is derived from San Diego costs, less 5 to 6 thousand dollars for the included secondary system.

The average cost for modification of an account truck for use in vapor balance service was $4,200.

Using these average and assumed values and an average number of account trucks for three levels of plant throughput, typical costs for installation of vapor balance systems at bulk plants were calculated and are presented in Table 6-5. The difference in costs related to throughput is a function only of the number of account trucks owned by the plant. For the largest bulk plant in terms of throughput (76,000 liters per day), the number of trucks is sometimes lower; i.e., in metropolitan areas where deliveries are close by, account trucks can make more rounds per day than in rural areas.

6.7 BENEFIT OF VAPOR RECOVERY

Typical bulk plants with 3 above-ground storage tanks with a capacity of 189,000 liters (50,000 gal) can lose up to 14.9 liters per day or 5,430 liters (1,450 gal) per year of gasoline vapors from

Table 6-5

INITIAL COST OF VAPOR BALANCE SYSTEM INSTALLATION

AVERAGE DAILY PLANT THROUGHPUT	3,800 liters[1] (1,000 gal)	15,000 liters[2] (4,000 gal)	76,000 liters[3] (20,000 gal)
Vapor Balance Application		Cost ($)	
INCOMING LOAD ONLY			
Underground Tanks	1,200	1,200	1,200
Above-ground Tanks	4,200	4,200	4,200
IN AND OUT LOADS			
Bottom-loading	25,000	30,000	40,000

(1) Assumes 1 account truck.
(2) Assumes 2 account trucks.
(3) Assumes 5 account trucks.

atmospheric-pressure storage tanks, due to breathing, regardless of throughput (Table 4-2). Assuming 90% elimination of breathing losses and 13 cents per liter (50 cents per gallon, which was a typical cost of gasoline to bulk plants as quoted by a few operators) for the cost of gasoline, annual savings would be $640.

Assuming 90% efficiency in the recovery of vapors and prevention of miscellaneous losses (Table 4-2) the following annual savings would result on the basis of 13 cents per liter of gasoline.

	DAILY THROUGHPUT		
	3,800 liters	15,000 liters	76,000 liters
		Savings per year ($)	
Tank working loss	200	810	4,060
Truck working loss	130	500	2,500
Miscellaneous loss	70	270	1,330

Based on the above assumptions of 90% control and recovery of emissions at bulk plants, the total annual savings at the bulk plant operators could be $1,040, $2,220 and $8,530 for average daily throughputs of 3,800 liters, 15,000 liters and 76,000 liters (1,000 gal, 4,000 gal and 20,000 gal) of gasoline, respectively. The savings which result from the control of losses due to incoming transfers (filling storage tank) are not realized by the bulk plant.

Benefits which may occur from other considerations were outside the scope of this study. These include benefits to the public health and welfare, potentially reduced fire hazards and driver safety.

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6-c Mr. Dixon, L.A. County Assessor, 500 W. Temple, Los Angeles, California

Mr. B. Canfield - Fresno County Assessor, 2281 Tulare St., Fresno, California.

6-d Bob Shuster, Shuster Oil and Chemical, Escondido, CA 92025

6-e D. Krinkle, Industrial Insurers, 6055 E. Washington Blvd., Los Angeles, CA

7. EFFICIENCY OF CONTROL ALTERNATIVES, MODELED

7.1 INTRODUCTION

Methods for estimating the effectiveness of vapor balance systems in reducing hydrocarbon emissions from gasoline bulk plant operations are presented and discussed in this section. These methods are reviewed in the context of development of a theoretical model for calculating control efficiencies of such systems given certain input data.

7.1.1 Principles of the Model

A model is developed which estimates the final temperature and pressure in both receiving and delivering tanks following a liquid transfer under ideal circumstances -- that is, given a vapor-balance system having 100 percent efficiency; these estimates are then used in estimating vapor losses due to perturbing conditions, such as leakage, heat transfer, thermal expansion and loss of line pressure. Possible effects of various perturbing conditions are dealth with in considerable detail. Results of this examination include:

a. a formula for estimating gasoline evaporation, with numerical examples

b. a review of various suggested methods of estimating the magnitude of losses due to leakage

c. a review of methods of estimating thermal effects from solar radiation and night-time cooling

d. a discussion of causes of the development of pressure head in vapor return lines

The effect of a secondary processor is expressed in terms of its efficiency in controlling vapors lost by the balance system. Section 7.2.1 develops the ideal estimates of final conditions. Section 7.2.2 evaluates the ideal assumptions and develops the procedure of deriving the incremental effects of the significant non-ideal parameters. Section 7.2.3 summarizes the model and its application to bulk plants.

7.1.2 Balance System Control Efficiency

A balance system primarily controls emissions from working losses. A simplified view of the mechanics of the system is that the volume of liquid lost by the draining tank is replaced by an identical volume of vapor from the filling tank which is displaced by the liquid gasoline. Another description is that by connecting the tank vapor spaces, a closed constant volume system is created. Control efficiency of this ideal system is identically 100% if nothing escapes from the closed system.

The two primary factors that disturb this ideal picture are leakage and limited system pressure capability. Both of these factors, under proper conditions, allow air-hydrocarbon mixtures to be emitted.

The primary condition which controls the amount of gases emitted is pressure. Gas pressure changes are a function of temperature, mass transfer to the atmosphere (air leakage into or gas leakage out of tanks and lines) mass transfer to the liquid gasoline (evaporation or condensation), initial pressure conditions, pressure drops in system and dynamic pressure transients. The effect of the factors on the efficiency of a balance system is discussed in conjunction with the model development in Section 7.2.

7.1.3 Secondary Processing Efficiency

The function of a secondary processing unit when used in conjunction with a balance system is to reduce the actual balance system emissions to achieve control (90% reduction). Secondary processing is normally not used unless the primary balance system is not capable of 90% control. The typical situation where a balance system may not be capable of 90% control is for vehicle refueling, where a closed system (especially at the refueling interface) is not readily achieved.

The application of a secondary processing unit to a bulk plant may serve a different primary purpose. The control of breathing losses may be the primary reason to install a secondary system. The added control of transfer losses may only be a secondary benefit. This is due to the fact that a bulk plant may more closely approach a closed system (for example, leak tight seals at refueling interface are available). Acceptable balance system control of transfer losses appears feasible.

Efficiency of a specific processing unit is highly dependent upon individual design, application and type of process. The efficiency of both types of processing units selected (refrigeration and adsorption) are dependent upon flow rates through the unit, presence of water vapor, and percentage and types of hydrocarbons in the flow. Refrigeration efficiency is further dependent upon ambient air temperature, coil surface area, fin design, use of regenerative heat exchangers, line insulation, control set points, and orientation. Adsorption efficiency is further dependent upon temperature of the adsorption bed, past history of the adsorption bed, overall and particle sizes, and supplier of adsorption material. The variability and lack of definition of many of these factors (only one operational prototype system) limits the discussion of efficiency of these systems to general terms.

Efficiency of a refrigeration system is primarily dependent upon how low a temperature can be imposed on the vapor stream. If saturated conditions are assumed, the true vapor pressure of the gasoline must be reduced by 90% in order to achieve 90% control efficiency. Thus, using Reference 4-a data for gasolines with a Reid vapor pressure of 10, cooling the vapors to -18°C (0°F) will control (condense) approximately 90% of the emissions from saturated vapors at 38°C (100°F) approximately 80% of emissions from saturated vapors at 21°C (70°F), but only approximately 60% of saturated vapors at 4°C (40°F). This indicates that if regulations are based on 90 percent control, independent of conditions,a refrigeration system would be required to cool the incoming vapors to very low temperatures under unsaturated wintertime conditions. This is further aggravated by wintertime gasolines which tend to have higher Reid vapor pressures, i.e., a larger percentage of light, more-difficult-to-condense hydrocarbons. Higher Reid vapor pressure gasolines are used to obtain adequate motor starting characteristics during winter. These difficulties are in addition to design problems of reevaporation of condensed vapors, nonuniform distribution of vapor temperatures, and nonuniform temperature of cooling coils.

Efficiency of an adsorption system is primarily dependent upon the availability of active sites in the adsorption material. Assuming that a new adsorption bed is capable of 90% control (at given input conditions), after an initial use, system will no longer be able to control 90% of emissions because some sites are now occupied. Efficiency will therefore be a function of the frequency of use and maintenance, i.e., the regeneration or replacement of the adsorption material.

Thus, the efficiency of selected secondary systems are primarily dependent upon variable and poorly defined factors. Both are capable of very high efficiencies. For purposes of modeling, however, only an overall efficiency term will be used. Term will be assumed an input, derived from specific manufacturer's certification data and/or analysis.

7.2 BALANCE SYSTEM MODEL

7.2.1 Ideal Assumptions

By creating a closed, constant-volume system, the final tank conditions will depend primarily on initial conditions of temperature and pressure and the liquid volume transferred. Final conditions will solely depend on these factors if the following ideal assumptions are employed:

- The air-hydrocarbon vapor mixture obeys the perfect gas laws
- The gas mixture is a constant
- There is zero gas leakage
- There is no heat transfer to and from the gas and the flow of vapors is frictionless and adiabatic
- There is no mass transfer (evaporation or condensation) to or from the liquid in the system
- There is no line-pressure loss
- There are no pressure transient effects during gasoline transfer operations
- No mixing of vapors takes place

Using these assumptions, final tank vapor conditions (mass volume, temperature, and pressure) can be predicted based on initial conditions and volume of product transferred. Using the mathematical expressions for these assumptions an ideal efficiency equation can be derived.

7.2.1.1 Derivation

$$\rho_0 = \frac{M_0}{V_0} = \frac{M_{ID} + M_{IF}}{V_{ID} + V_{IF}} = \frac{M_{CD} + M_{CF}}{V_{CD} + V_{CF}} \text{ (no mass transfer)}$$

$$P_{CF} = \left(P_{IF}\right)\left(\frac{\rho_{CF}}{\rho_{IF}}\right)^k ; \; P_{CD} = P_{ID}\left(\frac{\rho_{CD}}{\rho_{ID}}\right)^k \text{ (adiabatic relationships)}$$

$$P_{CF} = P_{CD} \text{ (no pressure loss)}$$

$$T_{CF} = \frac{P_{CF}}{R\rho_{CF}} ; \; T_{CD} = \frac{P_{CD}}{R\rho_{CD}} \quad \text{(perfect gas)}$$

$$T_{IF} = \frac{P_{IF}}{R\rho_{IF}} ; \; T_{ID} = \frac{P_{ID}}{R\rho_{ID}} \quad \text{(perfect gas)}$$

$$V_{CF} = V_{IF} - V_X ; \; V_{CD} = V_{ID} + V_X \text{ (incompressible liquids)}$$

Where:

K = Ratio of specific heats
P = Absolute pressure of vapors
T = Absolute temperature of vapors
M = Mass of gases
V = Volume of gases
ρ = Density of gases
R = Gas constant

Subscripts:

I = Initial conditions
C = Complete or final conditions
O = Overall gas conditions
D = Draining tank
F = Filling tank
X = Transferred

From adiabatic and no-pressure-loss relationships we get:

$$\rho_{CD} = \left(\frac{P_{IF}}{P_{ID}}\right)^{1/K} \left(\frac{\rho_{CF}}{\rho_{IF}}\right) \rho_{ID} \tag{7-1}$$

Using the conservation-of-mass relationships,

$$\rho_{CD} = \frac{\rho_O M_O - \rho_{CF} M_{CF}}{M_O - M_{CF}} \tag{7-2}$$

Where:

$$\rho_{CF} = \frac{M_{CF}}{V_{CF}} \tag{7-3}$$

Using incompressible liquid relationship and substituting equations 7-1 and 7-3 in 7-2 and solving for M_{CF} we get: (7-4)

$$M_{CF} = \frac{-M_0 + \sqrt{M_0^2 + 4\left[\left(\frac{\rho_{IF}}{\rho_{ID}}\right)\left(\frac{P_{ID}}{P_{IF}}\right)^{1/K} - 1\right]\left[\frac{\rho_{IF}}{\rho_{ID}}\left(\frac{P_{ID}}{P_{IF}}\right)^{1/K}\left(V_{IF} - V_X\right)\rho_0 M_0\right]}}{2\left[\left(\frac{\rho_{IF}}{\rho_{ID}}\right)\left(\frac{P_{ID}}{P_{IF}}\right)^{1/K} - 1\right]}$$

Note: If $\rho_{IF} = \rho_{ID}$ and $P_{ID} = P_{IF}$, then M_{CF} may be calculated by mass balance.

Equation 7-4 calculates the final mass of gas in filling tank from initial conditions and volume displaced. Initial values must be known (such as pressures) or calculated from known values (such as densities using perfect gas relationships).

Thus, vapor recovery efficiency, η_B is:

$$\eta_B = \frac{\left|M_{CD} - M_{ID}\right| 100}{\left|M_{IF} - M_{CF}\right|} \quad \text{(in percent)} \qquad (7\text{-}5)$$

These ideal equations establish the form of the final solution since, by definition, the efficiency of an ideal balance system is 100%. The non-ideal actual factors will be converted to incremental changes in mass and added (or subtracted) from the ideal formulation. Ideal estimates of final tank conditions, derived above, can be used in the equations to calculate the effects of non-ideal factors.

7.2.1.2 Secondary Processor

If a secondary processor is used to recover vapors lost from the balance system, the overall efficiency in percent can be expressed as:

$$\eta_0 = 100\left[1 - (1 - \eta_B/100)(1 - \eta_P/100)\right] \qquad (7\text{-}6)$$

Where:

η_0 = Overall efficiency, percent
η_P = Processor efficiency, percent
η_B = Balance system efficiency, percent

7.2.2 Evaluation of Assumptions

The applicability to small bulk plants for each ideal assumption listed in Section 7.2.1 is reviewed. If an actual condition should not be neglected, an incremental value is derived.

7.2.2.1 Perfect Gas

Assumption that the air-vapor mixture will behave as a perfect gas is generally valid as long as the gas condition is (1) not near saturated conditions or, (2) at moderate temperature and low pressure with respect to critical temperature and pressure.

The gas conditions with respect to (1) may well be close to saturated (Reference 7-a). The primary effect of these conditions is the potential for mass transfer (evaporation or condensation). However, a secondary effect is to vary the behavior of the gas, exclusive of mass transfer, with respect to perfect gas relationships. Reference 7-c indicates that errors of up to 5 percent may be present due to these conditions. Since this effect is secondary and the magnitude is small, this factor will be neglected. The primary effect of evaporation and condensation will be reviewed in Section 7.2.2.2.

The gas conditions with respect to the second factor appear to be well satisfied. Values for the ratio of expected temperatures and pressures, divided by critical values (per Reference 7-b) for typical gasoline vapor constituents (butanes and pentanes per 7-m) were calculated. Use of perfect gas relationships will result in only small errors (per Reference 7-c) using calculated values for critical value ratios.

7.2.2.2 Mass Transfer

A vapor balance system may be subject to mass transfer. The two prime areas for mass transfer to occur are (1) to and from the liquid gasoline (evaporation or condensation, solubility and absorption processes) and (2) to and from the ambient environment (leakage or suction, primarily). Leakage (or suction) will be discussed separately in Section 7.2.2.4.

Primary mass transfer to and from liquid gasoline is expected to be evaporation and secondarily, condensation. This is because of the following reasons (1) solubility or absorption of air in gasoline appears to be small (per Reference 7-k for similar fluids), (2) test data indicates vapor spaces are generally not completely saturated, (Reference 7-e,f), (3) pump and friction losses during transfer are converted into heat, (4) transfer process promotes circulation of liquid allowing fresh liquid surface to be exposed. This assumption is substantiated by test data showing vapor growth tendencies even with little temperature increase (Reference 7-j).

Heat transfer is a prime factor in evaporation and can cause rapid vaporization of a volatile liquid. As the liquid temperature increases, the vapor space warms, and the amount of hydrocarbon vapors and the pressure in the tank increase. The evaporation rate (mass transfer) can be viewed as being controlled by heat transfer. Since heat is removed by evaporation, an equal amount of heat must be added to the liquid to maintain a constant liquid temperature. This type of analysis is generally valid for large, turbulent rates of evaporation.

If evaporation rates are small and vapor space is quiescent, after the initial saturation of a small layer above the liquid, further evaporation only occurs after diffusion of vapors reduces the saturated concentration in the small layer above the liquid. This type of analysis is generally valid for very small evaporation rates which result in insignificant changes in temperature.

The real conditions inside the gasoline tanks are probably somewhere between these two extremes. However, the second (quiescent) analytical model will be used, since the typical tank conditions probably more closely approximate this model.

Assume a system where quiescent evaporation is taking place from the gasoline surface only. The basic diffusion relationship is given by Fick's Law of Diffusion which states that the mass flux of an element per unit area is proportional to the concentration gradient (Reference 7-k) or,

$$\frac{\dot{m}}{A} = -D \frac{dC_b}{dx} \qquad (7\text{-}7)$$

Where:

$\dot{m}$ = Mass flow, kg/hr

A = Area through which mass is flowing, m^2

D = Diffusion coefficient m^2/hr

dC_b = Incremental change in mass concentration of component B in kg/m^3

dx= Incremental distance, meters

However, this basic diffusion relationship is inconvenient to use directly. The actual concentration gradient near the liquid surface may continually change with time. Although time dependent solutions exist, the complexity does not seem justified for the amount of evaporation (mass flow) involved during transfer. A steady state gradient will be assumed. Average concentration will be assumed to be constant and located midway between the liquid surface and the top of the tank. Actual initial evaporation rate may be larger than the resulting calculated value but actual rate will eventually decay to zero, assuming no leakage. Thus, these assumptions represent a simplification and compromise. If ullage spaces are large, transfer times short, and some vapor space mixing occurs, calculated rate is probably an underestimate. If ullage spaces are small and transfer times are long, calculated rate may be an overestimate.

Fick's law may be expressed more conveniently in terms of partial pressures by making use of the perfect gas equation:

$$P = \rho RT$$

Where:

P = Pressure
ρ = Density
R = Constant
T = Temperature

The density ρ represents the mass concentration used in Fick's law. The gas constant R for a particular gas is given by the equation

$$R = \frac{R_u}{W}$$

Where:

R_u = Universal gas constant
W = Molecular weight of the gas

Therefore:

$$C_b = \frac{PW}{R_u T} \tag{7-8}$$

Substituting this equation in equation (7-7) and assuming that the temperature is constant,

$$\frac{\dot{m}_H}{A} = -D \frac{W_H}{R_u T} \frac{dP_H}{dx} \tag{7-9}$$

Where:

P_H = Partial pressure of hydrocarbon vapors

W_H = Molecular weight of hydrocarbon vapors

$\dot{m}_H$ = Difussion mass flow of hydrocarbon vapors

However, Fick's Law of Diffusion assumes a binary mixture diffusing in opposite directions. Because the tank conditions preclude the opposite direction flow of air, a convective transport term is also a component of the evaporation rate. Assuming constant or only incremental changes to total pressure and steady state, this total rate, known as Stefan's Law (Reference 7-p), is:

$$\frac{\dot{m}_H}{A} = \frac{DW_H}{R_uT} \frac{P}{P - P_H} \frac{dP_H}{dX} \qquad (7\text{-}10)$$

Where:

P = Total pressure in tank vapor space

Integration yields:

$$\therefore \dot{m}_H = \frac{DA}{R_uT} \frac{W_HP}{X/2} \log_e \left(\frac{P - P_S}{P - P_A}\right)$$

Where:

P_S= Saturated partial pressure of hydrocarbons

P_X= Average partial pressure of hydrocarbons at the top of the vapor space

X = Height of vapor space

This can be further simplified to (Reference 7-p):

$$\dot{m}_H = \frac{DA}{R_uT} \frac{W_HP}{X/2} \frac{(P_S - P_X)}{P_{ma}}$$

Where:

P_{ma}= Log mean air partial pressure

For small changes in air partial pressures only a small error is introduced by approximating P_{ma} as the average air partial pressure, P_a. Since m_H is assumed constant, equation 7-10 can be expressed as:

$$M = \frac{DA}{R_uT} \frac{W_HP}{X/2} \frac{(P_S - P_X)}{P_a} (t) \qquad (7\text{-}11)$$

Where:

M = Mass of hydrocarbons evaporated

D = Diffusion coefficient

A = Liquid surface area

R_u= Universal gas constant

T = Temperature

W_H = Molecular weight of hydrocarbon vapors

P = Total tank pressure

X = Vapor space height

P_S = Saturated partial pressure of hydrocarbon vapors

P_X = Initial average partial pressure of hydrocarbon

P_a = Average tank partial pressure of air

t = Time, in hours

Evaporation Example

Evaporation occurs during transfer of gasoline from a vertical storage tank 8 meters^2 (87 ft^2) in area and 8 meters (25 ft) high at 38°C and the mass is transferred in one hour. Assume RVP = 10 and average tank vapor space is 1/2 of tank height or 4 meters (12.5 ft). Assume initial partial pressure of hydrocarbons = 34,000 N/m^2 (5 psia).

Thus:

D = .03 m^2/hr (Reference 7-p, for compounds similar to hydrocarbon vapor constituents diffusing in air, $D \approx 1 \times 10^{-4}$ ft^2/sec)

A = 8 m^2

$R_u = 8{,}314 \frac{N - m}{kg - {}^\circ K}$ (1,545 ft -lb/lb - °R)

T = 294°K (70°F)

W_H = 66 (Reference 7-1)

P = 101,000 N/m^2 (14.7 psia)

X = 4 m

P_S = 43,000 N/m^2 (6.2 psia)

P_X = 34,000 N/m^2 (5.0 psia)

P_a = 67,000 N/m^2 (9.7 psia)

t = 1 hour

$$M = \frac{(.03)(8)}{(8{,}314)(294)} \; \frac{(66)(101{,}000)}{4} \; \frac{(43{,}000 - 34{,}000)}{67{,}000} \quad (1)$$

M = .02 kg (.05 lb)

Simplification

Further simplification for typical bulk plant application will be made by assuming negligible absolute temperature effects, negligible total pressure effects, converting area to a diameter term, D^2, and combining constants. A term K can be added to account for turbulence, if any. Term will be assumed equal to one, until test data can be used to provide further definition. Thus, for vertical tanks:

$$M = .13K \frac{D^2}{X} \frac{P_S - P_X}{P_a} (t) \qquad (7\text{-}12)$$

Where:

M = Evaporated mass, kg

K = Turbulence constant, assumed = 1

D = Diameter of cylindrical vertical tank, meters

X = Average height of vapor space, meters

P_S = Average saturated partial pressure of hydrocarbons N/m^2

P_X = Average initial tank partial pressure of hydrocarbons, N/m^2

P_a = Average initial tank partial pressure of air, N/m^2

t = Transfer time, hrs

For horizontal tanks, $\left(\frac{D^2}{X}\right)$ term must be replaced since the liquid surface area and vapor space geometry are changed. Liquid surface area will be a function of the height of liquid. For simplification, height will be assumed equal to the center of gravity of each tank half since during a complete filling (or draining) the surface area will be larger during 1/2 the time and smaller the other 1/2 (approximates the average). This height is $(\frac{D}{2} - \frac{D}{\pi})$, thus term $\frac{D^2}{X}$ can be replaced by

$$\frac{D^2}{X} \approx \frac{DL}{X} \qquad (7\text{-}13)$$

Where:

D = Cylindrical tank diameter, M

L = Length of horizontal tank, M

X = Average height of vapor space, M

Sample Calculations

CASE 1:

Assume hot incoming 38,000 liter (10,000 gal) load to bulk plant at 38°C (100°F), RVP = 10, vertical storage tank, tank vapor space is 80 percent of saturated conditions, diameter = 3 meters (10.5 ft) and tank height = 8 meters (26 ft). Tank initially has 15,000 liters (4,000 gal) stored at 21°C (70°F). Transfer time = 1 hour.

Thus:

K = 1 (assumed)
D = 3 meters, given

$X \approx 1/2$ of given tank height, 4 meters

P_S = Average saturated partial pressure, assumed equal to average of saturated initial 43,000 N/m^2 (6.2 psia at given temperature per Reference 7-q) and final partial pressures. Final saturated partial pressure is derived from weighted final gasoline temperature $\left[\frac{(21)(4,000) + 38\ (10,000)}{14,000}\right]$ = 33°C (91°F) , and Reference 7-q, = 63,000 N/m^2 (9.2 psia). Average saturated partial pressure = 53,000 N/m^2 $\left(\frac{6.2 + 9.2}{2} = 7.7 \text{ psia}\right)$.

P_X = 34,000 N/m^2 (80% of initial P_S of 6.2 psia = 5.0 psia)

P_a = 67,000 N/m^2 (14.7 psia less P_X of 5.0 psia = 9.7 psia)

t = 1 hour, given

Thus:

$$M = .13\ \frac{(3)^2}{4}\ \frac{(53,000 - 34,000)}{67,000} \quad (1)$$

$$= .08 \text{ Kg } (.18 \text{ lbs})$$

CASE 2:

Cold incoming load of 38,000 liters (10,000 gal) at 0°C (32°F) with saturated tank vapor space and all other conditions similar to Case 1.

Thus:

$D = 3$ meters, given

$X = 4$ meters

$P_S = 1/2$ (initial P_S + final P_S)

Initial $P_S = 43{,}000\ \mathrm{N/m^2}$ (6.2 psia at given temperature per Reference 7-q)

Final $P_S = 28{,}000\ \mathrm{N/m^2}$ (3.7 psia at 6.0°C or 43°F), thus

$P_S = 35{,}500\ \mathrm{N/m^2}$

$P_X = 43{,}000\ \mathrm{N/m^2}$

$P_A = 67{,}000\ \mathrm{N/m^2}$

$t = 1$ hour

Thus:

$$M = .13\ \frac{(3)^2}{4}\ \frac{(35{,}500 - 43{,}000)}{67{,}000} \quad (1)$$

$$= -.03\ \mathrm{Kg}\ (-0.07\ \mathrm{lb})$$

The negative sign indicates the mass of vapors condensed.

7.2.2.3 Constant Gas Mixture

The gases in the space above gasoline are a mixture. Mixture may vary by changes in state, air ingestion and mixing of gases. However, the simplification is probably acceptable for the following reasons: (1) differences in composition between truck and above-ground storage tank vapors are generally small (both tank temperatures strongly dependent upon ambient air conditions and both tanks containing similar RVP gasoline), and (2) changes in vapor composition due to changes in state during transfer are generally small. Thus, the assumptions of a constant gas mixture will be made.

However, only the loss of hydrocarbon vapors rather than the total mass of air-hydrocarbon mixture is of interest. Each mass in the mass balance will therefore be multiplied by the fraction of hydrocarbon vapors present.

Thus, equation 7-5 becomes:

$$\eta_B = \frac{(H_{CD}\ M_{CD} - H_{ID}\ M_{ID})\ 100}{(H_{IF}\ M_{IF} - H_{CF}\ M_{CF})} \qquad (7\text{-}14)$$

Where:

H = Mass fraction of hydrocarbon vapors

M = Ullage mass

η_B = Balance system efficiency

Subscripts:

C = Completed transfer conditions

I = Initial conditions

F = Filling tank conditions

D = Draining tank

Mass fraction H can be derived from volume fraction and relative densities. Volume fraction is directly related to partial pressures.

Thus:

$$H = N_V \frac{m_V}{\bar{m}_0} \qquad (7\text{-}15)$$

Where:

N_V = Volume fraction of hydrocarbon vapors, %

m_V = Average molecular weight of hydrocarbon vapors

m_0 = Overall molecular weight of gas

7.2.2.4 Zero Leakage

There is no such thing as absolutely zero leakage. Balance systems are available which, it is claimed, permit "insignificant" leakage when compared to flowrates in the order of 500 liters (130 gallons) per minute. (Reference 7-n).

Field and test data, however, indicate an opposite conclusion. Both San Diego and Boulder bulk plants tested (Reference 7-m) showed that there was significant leakage of vapors through PV valves and emergency vents. Reasons for these leaks may include: (1) insufficient maintenance of seals, (2) original hardware design requirements did not include low leakage, (3) improper modification or use of hardware, and (4) original system design and operation precluding a leak tight system. These reasons are discussed below.

Insufficient maintenance may be a significant factor. Questioning bulk plant operators on pressure-vacuum valve settings indicated that most have never performed maintenance or testing. Field inspection confirmed a general lack of valve maintenance (access screws were rusted or painted over). Although modern valves require little maintenance, none are guaranteed to last generations without maintenance.

Lack of low leakage design components may also be significant, especially for old plants. One of the original and major reasons for requiring a pressure-vacuum valve on above-ground tanks was for fire safety (restricting ingestion of a spark). Underground tanks are generally not required to have pressure-vacuum valves (nearly zero breathing and no tank exposure to exterior fire). Leakage of these old valves may have been only a secondary consideration. Modern valves also have the advantage of improved seal materials (fluoroelastomers, for example).

Very few cases of improper modification or use of hardware were noted; however there was no effort to discover the extent of improper use or modifications. Few operators could be expected to report improper use or modifications in response to telephone inquiries or allow discovery after being notified of impending tests or field inspections.

Leakage due to inadequate system design and operation is probably another significant factor. Typical operations which cause loss of hydrocarbons include opening tank hatches to measure or verify transfer of gasoline, priming of pumps with venting of vapors and loss of liquid, use of open catch buckets for leakage or spills. In modern operations, remote temperature and liquid level storage tank instrumentation, sight glasses in truck product lines to verify complete transfer, and submerged pumps in underground tanks help to reduce such losses.

For modeling purposes, leakage must therefore be considered. Although various leakage flow models are available, significant leakage rates (10^5 standard cubic centimeters per minute) are generally assumed to be equivalent to orifice or nozzle flow (Reference 7-s) One additional input will be required to calculate the leakage flow (pressures and temperatures already required in ideal calculations). This required input is the size of the orifice (diameter). This can vary from zero to the size of an access hatch cover, inadvertently left open. Reference 7-m estimated two leakage rates of 3 and 1/2 cubic feet per minute (cfm). The corresponding orifice can be calculated using the following form of the orifice flow equation (Reference 7-f):

$$q = 412 \frac{Y d^2 C}{sg} \sqrt{\Delta P \rho_1} \qquad (7\text{-}16)$$

Where:

q = Rate of flow, in cubic feet per minute

Y = Net expansion factor for compressible flow through orifices

d = Internal diameter of orifice in inches

C = Flow coefficient for orifices, dimensionless

ΔP= Differential pressure between two points, psi

ρ_1= Initial weight density of fluids, lb/cu ft

sg= Specific gravity relative to air, dimensionless

Assuming flow rate of saturated vapors through leak = 3 cfm and temperature of gasoline vapors = 80°F,

Where:

ΔP = .24 psi (6" H_2O per Reference 7-m)
Y = 1 (Reference 7-f)
C = 0.6, based on assumed type of orifice (Reference 7-f)
M = 66, molecular (Reference 7-o)
$\rho_1 = \frac{66(7.5) + 29(7.2)}{14.7} (.002788) = .133 \text{ lb/ft}^3$ (Reference 7-c)
sg=1.77
q =3 cfm (Reference 7-m)

Thus:

$$3 = \frac{412 \times 1 \times d^2 \times 0.6}{1.77} \sqrt{.24 \times .133}$$

$d^2 = .12$; d = 0.35 inches or .0088 meters

Similarly, for 1/2 cfm:

d = 0.14 inches or .0036 meters

It should be noted that these leakage rates are quite severe. 1/2 cfm and 3 cfm leaks would be equivalent to losing 3% and 17% respectively of the displaced vapors at a typical transfer rate of 130 gal/min and standard conditions. However, the loss of mass would lower the tank pressure which would lower the leakage but also encourage further evaporation. Steady pressures will be assumed for simplicity but accuracy will be limited to leak rates approximating a very small percent of the vapor volume.

These values of orifice size cannot be assumed to be typical, given the small test data base. However, orifice sizes in this order of magnitude do not seem unreasonable. Simplification of the equation (7-16) and conversion to metric units can therefore be accomplished by limiting the equation to the significant variables of time, pressure and orifice diameter. Thus, for tank pressure greater than ambient:

$$M_H = 3,300\ t\ d^2\sqrt{\Delta P} \qquad (7\text{-}17)$$

Where:

M_H= Mass of air-hydrocarbon vapors emitted (leaked during transfer, kgs

t = Time, hours

d = Assumed orifice size, meters

ΔP= Average pressure difference, tank less ambient, N/m^2

Note: Assumes vapors are saturated at (21^oC).

Similarly, if tank pressure is less than ambient (vacuum):

$$M_V = 2,600\ t\ d^2\ \sqrt{\Delta P} \qquad (7\text{-}18)$$

Where:

M_V= Mass of air entering tank during transfer, kgs

t = Time, hours

d = Assumed orifice size, meters

ΔP= Average pressure difference, ambient less tank, N/m^2

If larger leakage (orifice size) is anticipated, the mass leaked will be equivalent to changing the tank pressures to ambient, thus, assuming isothermal discharge:

$$\frac{M_T - M_L}{M_T} = \frac{P_A}{P_T} \quad \text{or} \quad M_L = M_T - \frac{P_A}{P_T}\ M_T \qquad (7\text{-}19)$$

Where:

M_L= Mass of air-hydrocarbon mixture transferred

M_T= Mass of air-hydrocarbon vapors in tank

P_A= Ambient pressure, absolute

P_T= Actual tank pressure, absolute

If actual tank pressure is less than ambient, for simplicity, the same equation will be used. This simplification assumes that the amount of air ingested (negative M_L) is small compared to the mass of vapors in the tank (M_T). The assumption is made since tank operating pressure range is generally positive ($P_T > P_A$), composition of vapors in vapor space with large leaks will tend to be predominantly air and vacuum settings on pressure-vacuum valves are low.

Another potential source of emissions or ingestion of air is if the operating pressures in the tanks exceed the relief settings of the pressure-vacuum valve. The amount of emissions will be approximated similar to equation 7-19 except that the ambient pressure term will be replaced with the relief settings when tank pressure exceeds settings.

Thus:

$$M_R = M_T - \frac{P_R}{P_T} M_T \qquad (7\text{-}20)$$

Where:

M_R= Mass of air-hydrocarbon vapors emitted or air ingested (if negative)

M_T= Mass of air-hydrocarbon vapors in tank

P_R= Pressure or vacuum relief set point of tank

P_T= Actual tank pressure

Note that equation 7-20 cannot be used if large leakage (7-19) is present. 7-20 should be used when only small leakage (equations 7-17 and 7-18) is present.

Whether the orifice is large enough to reduce the tank pressure to ambient can be determined by the use of pressure response equations

Pressure response equations can be written in the form (Reference 7-s)

$$R_t = C\left(\tau_f - \tau_i\right) \qquad (7\text{-}21)$$

Where:

R_t = Time, seconds

C = Constant for process and gas

$\tau_f - \tau_i$ = Difference of the subcritical flow integrals

Isothermal venting will be assumed for simplicity and significance of heat transfer ability (see Section 7.2.3.5) of tank walls. For isothermal venting, C is equal to (Reference 7-s):

$$C = \frac{V}{C_1 \; C_D \; A_o \; R\sqrt{T}}$$

Where:

C = Constant, seconds

V = Volume of tank, ft^3

$$C_1 = \sqrt{\frac{\gamma g}{\left(\frac{G_C}{G}\right)}\left(\frac{2}{\gamma + 1}\right)^{\gamma + 1/\gamma - 1}} \quad , \quad \frac{\sqrt{°R}}{sec}$$

C_D = Discharge coefficient, dimensionless

G = Accleration of gravity, ft/sec^2

G_C = Gravitational constant, ft/sec^2

A_o = Throat area, ft^2

R = Gas constant, $\frac{ft - lb}{lb - °R}$

T = Tank temperature, °R

γ = Ratio of specific heats , dimensionless

Substituting typical values for terms not expected to significantly vary,

$C_1 = .44$

$C_D = .6$

$R = 44 \; \frac{ft - lb}{lb - °R}$

$T = 530°R$

$$\therefore C = .004 \; \frac{V}{A}$$

$(\tau_f - \tau_1)$ will be approximated, using figures in Reference 7-s, as $.5\left(\frac{P_T}{P_A}\right)$

Where:

P_T= Tank pressure, absolute
P_A= Ambient pressure, absolute

Thus:

$$R_t = .004\left(\frac{V}{A}\right)\left(.5\,\frac{P_T}{P_A}\right)$$

Converting V to liters, t into hours, and A to orifice diameter in meters:

$$R_t = 2 \times 10^{-9}\left(\frac{V}{D^2}\right)\left(\frac{P_T}{P_A}\right) \qquad (7\text{-}22)$$

Where:

R_t= Response time, hours
V = Total vapor space volume, liters
D = Assumed leak orifice, meters
P_T= Initial tank pressure, absolute
P_A= Ambient pressure, absolute

Similarly, when tank pressure is less that P_A,

$$R_t = 3 \times 10^{-9}\,\frac{V}{P^2}\left(\frac{P_A}{P_t}\right) \qquad (7\text{-}23)$$

Therefore, if response time calculated from pressure response equations 7-22 or 7-23 is much larger than the transfer time, use steady state equations (7-17 or 7-18) to estimate the leakage. If response time calculated is in the order of transfer time or less, use large leak equation (7-19) to estimate leakage.

7.2.2.5 No Heat Transfer and Vapor Flow is Frictionless

The effect of friction is to convert kinetic energy (flowing vapors) input into heat energy. The loss of kinetic energy can be related to the vapor line pressure loss (ΔP). But for typical bulk plant vapor line ΔP (Section 7.2.2.10), the resultant heat energy dissipated due to effect of friction is small compared to the heat capacity of the vapors and hence the effect of friction shall be neglected.

The ideal model uses adiabatic expansion or compression. The validity of this assumption is primarily dependent on the lack of significant heat transfer occuring during the gasoline transfer. Transfer of heat will primarily occur at the tank walls, in the interconnecting lines and at the liquid interface. No measurements of heat transferred during loading and unloading could be found, but test data on vapor temperatures during transfer indicates significance. Liquid gasoline and vapor temperatures can be changed by initial wall temperatures, and ambient air connection and solar radiation.

Initial Wall Temperature Heat Transfer

Liquid gasoline contacting exposed tank or transfer line walls will be initially assumed to come to equilibrium with these surfaces. This assumption is made because of the high heat transfer coefficient of flowing liquids. A further assumption will be made that the wall temperatures will change to something close to [illegible] initial liquid temperature. This assumption is made because the specific heat of gasoline, S_G(.05 BTU/lb-°F, per Reference 7-c), times the amount typically transferred is large compared to the specific heat of lines, S_P, or walls, S_W (0.1 BTU/lb-°F, per Reference 7-c) times the weight.

Thus:

$$(\Delta T_G)\, S_G\, M_G = (T_P - T_G)\, S_P\, M_P + (T_W - T_{AG})\, S_W\, M_W \qquad (7\text{-}24)$$

Where:

ΔT_G = Incremental change in liquid temperature, °C

S_G = Specific heat of gasoline, 500 cal/kg/°C

S_P = Specific heat of plumbing 100 cal/kg/°C

S_W = Specific heat of tank walls, 100 cal/kg/°C

M_G = Mass of gasoline, kg, $= \rho_G V_T$

ρ_G = Density of gasoline, kg/liter

V_T = Volume transferred, liters

M_P = Mass of transfer lines (plumbing), kg

M_W = Mass of exposed walls, kg

T_P = Initial transfer line temperature °C

T_G = Initial temperature of gasoline to be transferred, °C

T_W = Initial exposed tank wall temperature, °C

T_{AG} = Average final gasoline temperature in tank, °C

Substitution of typical transfer conditions (500 liters/min or 130 gal/min) yields a ΔT of less than .6°C (1°F) for an initial difference of 16.7°C (30°F). Therefore, contribution will be ignored.

The same analysis can not be used for vapors because the mass and specific heat of vapors is much smaller and the coefficient of heat transfer is also smaller. Transfer of heat will therefore be assumed to be controlled by convection from the tank walls to the vapor.

Convection Heat Transfer

Additional heat can be transferred through the tank and plumbing walls by air convection. Reference 7-g gives typical ambient air convective heat transfer coefficient as 1.3 to 7 gm-cal/sec-M^2-°C (1 to 5 BTU/hr-ft^2-°F). Again assuming typical transfer conditions (500 liters/min or 130 gal/min) and a 16.7°C (30°F) initial temperature difference, liquid gasoline temperature difference will change less than .6°C (1°F) and will therefore be ignored.

Heat transfer from the tank walls to the vapors will be assumed to be at rates similar to ambient air convection (1.3 to 7 gm-cal/sec-m^2°C or 1 to 5 BTU/hr-ft^2-°F). This simplification is made because velocities in the vapor space are probably low during transfer (typical 500 liter/min pump flow converts to only 0.06 meters/min or 0.2 ft/min in vertical storage tanks), and the majority of the composition by volume of the typical vapor space is air. Assuming typical transfer conditions, and a constant wall temperature, the vapor space will approach the wall temperature because of the small gas heat capacity compared to the rate of heat transfer. These factors apply even more strongly to transfer line conditions because of the higher forced convective heat transfer coefficient. Since the heat capacity of the tank walls and piping is large compared to the heat capacity of the vapor, the vapor temperature in the draining tank will be assumed equal to the average tank wall and transfer piping temberature, if no other source of heat (or sink) is available. Average vapor wall temperature during transfer will be dependent upon ambient air convection. For typical tank wall construction (0.46 cm or 0.18 inch per Reference 7-4) or pipe wall construction (.55 cm or .216 inch for standard three inch diameter pipe per Reference 7-c) the heat capacity of the wall per unit area (approximately 0.0004 cal/m^2-°C, or 1 BTU/ft^2-°F) approximates the heat transferred for typical transfer times (1.3 to 7 cal/sec-°C or 1 to 5 BTU/ft^2-hr-°F). Therefore, the final wall temperature will be assumed to be halfway between the initial wall temperature and ambient air temperature, if no other heat source (or sink) is present.

Radiation Heat Transfer

Solar radiation is another potential heat input during transfer. Again, no directly applicable data is available. The heat transferred depends upon latitude, time of year, time of day, altitude, shade factor, surroundings (reflected radiation), cloud and haze factors, diffuse (sky shine) radiation and absorption coefficient of surface. It will also involve initial conditions, actual direct irradiated area, diffuse radiated area, conduction, convection and re-radiation of heat.

In order to handle these factors, the following simplification will be made. A change in wall temperature (ΔT) due to radiation will be added to the wall temperature. Although using severe assumptions and values from Reference 7-g and 7-i. The range of this ΔT during summer can be from -10°C for a clear night transfer, to +19°C for clear midday transfer, more typical values of summertime ΔT are probably in the range of ±0 to 6°C. Similarly severe winter values of ΔT can range from +11°C to -4°C, but more typical values are probably ±0 to 3°C.

Liquid-Vapor Heat Transfer

Heat transfer to and from the liquid is significantly influenced by the change in phase previously discussed. In addition to changes in state, heat is also transferred by convection. Convective heat transfer coefficient will be assumed to be 1.3 to 7 gm cal/sec-m^2°C (1 to 5 BTU/ft^2-hr-°F), and temperature of the liquid a function of initial temperatures only because of the large heat capacity. The final vapor temperature change in the filling tank, exposed to a change in liquid temperature, will be assumed to approximate the average liquid temperature. This assumption is because of the small vapor heat capacity compared to heat transfer potential during typical transfer conditions.

Effect on Mass in Tanks

The change in pressure resulting from these changes in vapor temperature can be estimated by the perfect gas law, assuming the density remains constant.

Thus,

$$\Delta P = \rho R \Delta T \qquad (7\text{-}25)$$

This change in tank pressure will have no effect on balance system efficiency unless leakage or venting occurs. If leakage potential is present (see Section 7.2.2.4), the change in tank pressure will therefore be included in the tank pressure terms.

Thus.

$$\Delta P_X = \rho R \; (\Delta T_R + \Delta T_F + \Delta T_D) \qquad (7\text{-}26)$$

Where:

ΔP_X = Change in pressure due to heat transfer, N/m^3
ρ = Tank gas density, kg/m^3
R = Gas constant, 8.314 (N - m/kg - °K)/average mole wt
ΔT_R = Radiation temperature change, 0 to ± 6°C (input dependent upon time of day, season, transfer time, cloud cover and tank surface)
ΔT_F = Filling tank vapor temperature change, $\dfrac{(T_{IW} + T_A)/2 + T_L}{2} - T_V$, °C
ΔT_P = Draining tank vapor temperature change $\left[(T_{IW} + T_A)/2\right] - T_V$, °C
T_{IW} = Average initial wall temperature, °C
T_A = Ambient temperature, °C
T_L = Temperature of liquid gasoline, °C
T_V = Entering Vapor temperature, °C

7.2.2.6 Incompressible Liquid and Tankage

Liquid compressibility will be approximated as $10 \times 10^{-10}/\mathrm{Nm}^{-2}$ per Reference 7-b ($8 \times 10^{-3}/_{\mathrm{atm}}$ for n-octane). Typical operating pressure range of tanks, however, is small. Thus, a change in pressure of 1,700 $\mathrm{N/m}^2$ (4 $\mathrm{oz/in}^2$) for 38,000 liters (10,000 gallons) will only change the volume by 0.07 liters (0.018 gallons). Liquid compressibility will therefore be ignored.

Tank volume changes due to pressurization are similarly small. The tank modulus of elasticity will be assumed to be 2×10^{11} $\mathrm{N/m}^2$ (30×10^6 psi). Thus, a change of 1,700 $\mathrm{N/m}^2$ (4 $\mathrm{oz/in}^2$) on a three-meter (10.5 ft) diameter tank, with 0.0046m (0.18 in) walls will only increase the circumference by 0.00003 meters (0.0001 ft). Tank compressibility will therefore be ignored.

7.2.2.7 Thermal Expansion

Another factor tending to change tank volumes is the change in temperature. A volume factor of 0.0011/°C (0.00061/°F) for gasoline is used by Standard Oil of California and Conoco. This factor will not be ignored since for a 16.7°C (30°F) increase in liquid temperature, about 2 percent of the transferred air containing vapors will be expelled if the pressure and temperature of vapors are constant.

The tanks will also grow and shrink with temperature. However, magnitude is in the order of 0.000036/°C (0.00002/°F) for a 3.2m (10 1/2 ft) diameter, 9 meter (30 ft) high tank assuming a linear coefficient of expansion is $0.1008 \times 10^{-4}/°\mathrm{C}$ ($0.056 \times 10^{-4}/°\mathrm{F}$) for steel (Reference 7-c). This results in a volume change of 0.06 percent for a temperature change of 16.7°C (30°F). Tank wall thermal expansion will therefore be ignored.

Thus a change in volume factor, ΔV will be defined as follows for filling tank

$$\Delta V_F = .0011 \left[\left(\frac{T_{ILX}M_{LX} + T_{ILF}\ M_{ILF}}{M_{LX} + M_{ILF}}\right) - T_{ILF}\right]\left[V_{IF} + V_X\right] \quad (7\text{-}27)$$

Where:

ΔV_F = Change in volume, liter

T_{ILX} = Initial liquid temperature of transferred gasoline, °C

T_{ILF} = Initial liquid temperature of gasoline in filling tank, °C

M_{LX} = Mass of liquid gasoline transferred.

M_{ILF} = Initial mass of liquid gasoline in filling tank

V_{IF} = Initial volume of liquid gasoline in storage tank

V_X = Volume of liquid gasoline transferred

Effect on tank pressure, assuming isothermal conditions is as follows:

$$\Delta P_V = \frac{\Delta V_F}{V_T} P_T \quad (7\text{-}28)$$

Where:

ΔP_V = Incremental change in pressure

ΔV_F = Result from (7-27)

V_T = Initial tank ullage volume

P_T = Initial tank pressure

It must be noted that the volume change in the draining tank (incoming) is unchanged. For outgoing transfers, the account truck will be assumed nearly empty and change in temperature of the liquid can be assumed to be insignificant.

7.2.2.8 No Mixing of Vapors

This assumption appears to be valid for the vapors left in the tank being filled, but appears to be poor for draining tank. Ideal model assumes the temperature of the vapors entering the draining tank will not mix (change in temperature). Mixing would vary the tank pressure. However, the previous discussion of heat transfer (Section 7.2.2.5) indicates that any effects of vapors mixing in the draining tank will probably be overwhelmed by the effects of heat transfer. The effects of vapors mixing will therefore be ignored.

7.2.2.9 Transient Effects

Actual vapor balance system can be subjected to transients during startup or shutdown of gasoline transfer operations.

A tank nearly full of gasoline may, upon draining, create a vacuum, until returning vapors (from tank being filled) have time to establish a significant flow rate. Depending on pump starting characteristics, system response time (primarily a function of speed of sound and total line length) and damping characteristics (primarily a function of ullage and flow resistance), the compensating rush of return vapors may then over pressurize the draining tank. Similarly, the filling tank may experience large pressure excursions when nearly full and flow is rapidly stopped. However, because typical (old) pumps do not start instantly, typical response times are short, and tanks are not generally filled completely (newer trucks and facilities have float valve, or sensors preventing overfilling as well as slowing flow at end of delivery), typical vapor transient effects are not expected to be significant, and will be ignored in model and emission factors.

7.2.2.10 Line Pressure Loss

An important factor in a vapor balance system can be the pressure loss in the vapor (return) lines. The reason for this importance is the potential for exceeding the tank operating pressure range causing potential emissions of vapors in the filling tank and suction of air in the draining tank. If leakage is present, losses are magnified.

Line pressure loss analysis for typical flows and vapor return line conditions indicates that the actual pressure loss is primarily a function of the valves, connectors and miscellaneous fittings chosen, rather than frictional loss in the straight lengths of piping. Some vapor return piping systems observed or documented have included check valves (to prevent reverse flow of vapors), flame arrestors, dry breaks (valves which close upon disconnecting piping at truck/plant interface), hand valves, and various types of connectors.

Critical loss factor is the pressure drop through a check valve in the vapor line if present. The use of a check valve precludes an operator forgetting to open or close valves but typical check valves create pressure loss in the order of 3400 N/m^2 (0.5 psi). This is significant when compared to vacuum or pressure settings of storage tanks and trucks. Even though lower ΔP check valves are available, the inherent loss in pressure is not desirable. Most balance systems observed did not include check valves.

The presence of a flame arrestor also creates a pressure loss. Although flame arrestors are used in the petroleum industry as a safety measure, most bulk plants surveyed did not use flame arrestors. Flame arrestors require a flow restriction (generally a corrugated or screen element) in order to function. They may not properly function in long lines, and are subject to blockage due to contamination and freezing. American Petroleum Institute (PSD 2210, May 1971) does not recommend their use. Most balance systems observed did not include flame arrestors.

Certain types of valves (globe, for example) have higher pressure loss than other types (gate or ball, for example). However, the absolute magnitude of the loss is not large and higher loss valves may offer advantages of higher reliability, smaller leakage, lower cost and availability. Therefore, although gate or ball valves are desirable for low loss vapor line service, use of other types does not appear to be precluded due to pressure loss.

Pipe fittings can be supplied in low pressure loss (long radius elbows, for example) and high loss versions (square corner, for example). Again, other considerations (space availability, for example) may dictate use of high loss versions. Magnitude of the losses from high loss fittings again do not preclude their use, even though lower loss fittings are desirable.

The use of a coupling with dry breaks also creates a greater pressure loss than an open coupling. However, the advantages of reliable operation (no separate valves to open), no loss of line vapors upon disconnection, and potential replacement by 2 separate valves with possibly higher pressure losses, suggest the desirability of dry breaks. Other considerations such as confusion between liquid and vapor dry breaks and lower potential reliability (leakage) due to rough handling, as well as cost may dictate non-use. Again, presence or absence does not appear to be critical since the magnitude of the pressure loss at typical bulk plant conditions is small.

In conclusion, if only a little care in the design of the vapor return lines is used (no check valves or small flame arrestors with at least 6.1 cm (2 in) diameter properly sloped lines) a typical pressure loss on the order of 1000 newtons/square meter (0.1 psi) can be achieved. If 7.6 cm (3 in) diameter line size is used such losses should be in the order of 100 newtons/square meter (.01 psi). Most of the installations surveyed seemed to meet these criteria.

These losses must be compared to typical storage tank pressure vacuum valve set points. Using an operating pressure range of 1700 N/m^2 (4 oz/in^2), it can be seen that a typical 5.1 cm (2 in) diameter line (1000 N/m^2 pressure drop) may present a significant chance of emitting vapors or drawing air into the tanks. This chance is dependent upon the initial pressure in the tanks. A typical 7.6 cm (3 in) line (100 N/m^2 pressure drop) will have little chance of expelling vapors or ingesting air under steady state conditions.

Line loss factor will therefore be related to the nominal pipe size of the vapor line. The effect of the loss (pressure) if significant, will be included in the leakage terms defined in Section 7.2.2.4. One-half of total will be added to the filling tank and one-half will be subtracted from the draining tank. Thus

$$\Delta P_F = \Delta P_X/2 \qquad (7\text{-}29)$$

$$\Delta P_D = -\Delta P_X/2 \qquad (7\text{-}30)$$

Where:

ΔP_F = incremental pressure change in filling tank pressure

ΔP_D = Incremental pressure change in draining tank pressure

ΔP_X = Transfer line pressure drop, a function of line size and hardware configuration

7.2.3 Incremental Model Usage

The ideal solution will be modified by the significant increments developed in the preceding section. Inputs required for usage (with typical valves if data not available in parenthesis) are detailed and procedure for usage documented.

7.2.3.1 Inputs

V_D = Total volume of draining tank, liters (64,000 liters for storage tanks, 38,000 liters for incoming trucks, 7,000 liters for account trucks)

V_F = Total volume of filling tank, liters (64,000 liters for storage tanks, 38,000 liters for incoming trucks, 7,000 liters for account trucks)

V_{XG} = Volume of liquid gasoline transferred, liters (34,000 liters incoming, 6,000 liters outgoing)

V_{1D} = Initial volume of ullage in the draining tank, liters (4,000 liters for incoming trucks, 32,000 liters for storage tanks)

V_{1F} = Initial volume of ullage in the filling tank, liters (49,000 liters for storage tanks, 6,000 liters for account trucks)

V_A = Ambient temperature, ^oC (21^oC)

ΔT_R = Radiant temperature increment, ^oC (0 to $\pm$ 6^oC depending on time of day, season and cloud cover)

T_D = Vapor wall temperature of draining tank, ^oC (21^oC)

T_F = Vapor wall temperature of filling tank, ^oC (21^oC)

T_X = Temperature of vapor (return) line, ^oC (21^oC)

T_{GD} = Initial temperature of liquid gasoline in draining tank, ^oC (21^oC)

T_{GF} = Initial temperature of liquid gasoline in filling tank, ^oC (21^oC)

H_D = Initial volume percentage of hydrocarbons vapors in draining tank ullage, % (30%)

H_F = Initial volume percentage of hydrocarbons vapors in filling tank ullage, % (30%)

RVP = Reid vapor pressure of gasoline (10)

D_F = Diameter of leakage orifice in filling tank, meters (0 to 1 meter depending upon age, maintenance and equipment).

P_{SF} = Filling tank pressure - vacuum valve pressure set point, Newtons/ square meter (2,000 N/M^2 or 5 oz/in^2, gauge or 103,300 N/M^2 absolute)

P_{SD} = Draining tank pressure vacuum valve pressure set point, Newtons/square meter (2,000 N/M^2 or 5 oz/in^2, gauge or 103,300 N/M^2 absolute

P_{VF} = Filling tank pressure vacuum valve pressure set point, Newtons/square meter (200 N/M^2 or .5 oz/in^2 gauge, or 101,100 N/M^2 absolute)

P_{VD} = Draining tank pressure vacuum valve vacuum set point, Newtons/square meter (200 N/M^2 or 0.5 oz/in^2 gauge, or 101,100 N/M^2 absolute)

P_{IF} = Initial filling tank pressure, Newtons/square meter $\leq P_{SF}$, $\geq P_{VF}$, depending on time of day, leakage, etc.)

P_{ID} = Initial draining tank pressure, Newtons/square meter ($< P_{SD}$, $\geq P_{VD}$, depending on time of day, leakage, etc.)

ΔP_X = Transfer line pressure loss increment, Newtons/square meter (100 N/M^2 for 2 inch nominal lines, 1000 N/M^2 for 3 inch nominal lines)

t = Transfer time or V_{XG} divided by pump flowrate plus set-up time, hours (incoming = 1 hour, outgoing = 0.2 hours)

7.2.3.2 Procedure

a) Calculate ideal final tank conditions (equations 7-1, through 7-4).

b) Add incremental effects of evaporation or condensation (equation 7-12), and calculate pressure increments due to heat transfer (equation 7-26) thermal expansion (equation 7-28), and line loss (equations 7-29 and 7-30).

c) Calculate pressure response time (equations 7-22 and 7-23) and compare calculated time to transfer time, if response times are much larger than transfer time, use steady flow leakage calculations (equations 7-17 and 7-18) and relief calculations (equations 7-20). If response times are in the order of the transfer time or less, use large leak calculations (equation 7-19, only, to estimate changes in mass.

d) Add incremental changes in vapor masses to ideal efficiency equation and calculate balance system efficiency per equation 7-14.

e) If a secondary processing unit is used, calculate efficiency per equation 7-6.

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8. CONCLUSIONS

8.1 INVENTORY

The typical bulk plant in the specified AQCR's is a small specialty retailer of petroleum products. Incoming product is delivered by a tank truck and trailer. The major portion of the gasoline sales are to small agricultural accounts, delivered by a few small account trucks. Gasoline thoughput is 15,000 liters (4,000 gallons per day.

8.2 TYPICAL FACILITIES

Typical gasoline storage consists of three above-ground, fixed-roof tanks. Account trucks are generally top loaded. Facilities are generally old. Underground tank storage represents a slowly growing minority.

8.3 INDUSTRY TRENDS

The bulk plant industry seems to be under strong economic pressure, independent of emission control regulations. This pressure is manifested by the closing of small bulk plants.

8.4 EMISSIONS

Significant uncontrolled hydrocarbon vapor emissions are caused by breathing and fugitive losses as well as the transfer-of-gasoline working loss. Fugitive emissions, such as liquid spillage and leakage, are highly variable. Most regulations relate only to working losses.

8.5 CONTROL ALTERNATIVES

Working loss can be controlled (90% reduction in emissions) by a balance system. A submerged fill will reduce but not control working loss and is common in the surveyed areas. Breathing loss can be reduced but not controlled by small increases in tank operating pressure. Some secondary (vapor processing) systems can control breathing loss and improve control of working loss. Other alternatives exist, but require development. Fugitive loss can be controlled primarily by proper maintenance. Safety of some control alternatives requires further development and verification.

8.6 CONTROL COSTS

Balance system for incoming transfer of gasoline has cost an average of $4,300 in the surveyed areas. Submerged fill and a small increase in operating pressure can be accomplished with little incremental cost. Installing a balance system for outgoing transfer of gasoline (at the loading rack) has been quoted to cost in the order of $40,000. However, the validity of this cost is uncertain because of 1) the included cost of converting from the top loading to bottom loading, and 2) the small but highly variable data base. Vapors can be controlled without converting to bottom loading and the few quoted top-loading costs were significantly less than control costs including conversion. The portion of these conversion costs ascribable to vapor control is uncertain. The large variability in costs appears to be related to the age of the bulk plants. Again, the portion of the quoted vapor control cost which would have been for normal maintenance and repair of old facilities is uncertain. Other factors include learning curve, self installation, and other included modifications.

The assumption was made that San Diego, California, cost data represented a valid estimate of the expected costs. This generally includes bottom-loading conversions. The resulting facility cost is in the order of $20,000. Conversion of account trucks raises the total initial cost to a typical independent bulk plant to approximately $30,000. Addition of a secondary system would add another $6,000 to the total cost.

8.7 CONTROL SYSTEM EFFICIENCY AND MODEL

Balance system efficiency (working loss only) is primarily dependent upon vapor leakage. Although leakage can be essentially eliminated, test data indicates it is significant. Model analysis indicates other factors (heat transfer, temperature changes, pressure losses, phase changes) are not generally critical to efficiency. Secondary control system efficiency is dependent upon specific equipment design and application.

8.8 AREAS FOR FURTHER EFFORT

Breathing losses for trucks and customer tanks are not well defined. A reduction of emissions appears feasible with relatively inexpensive methods, such as insulation and increased operating pressure.

Several control concepts appear promising for certain applications but require development. These include bladders, insulation and holding tanks. Feasibility studies seem desirable.

The portion of bottom-loading conversion cost ascribable to vapor control regulations is uncertain. Detailed cost breakdowns would be required to define the proportion of total costs.

Application of data base to other AQCR's and effect of regulation exemptions are not well defined. Data from other AQCR's would be required.

9. GLOSSARY

● ACCOUNT TRUCKS	Tank trucks used to deliver gasoline to customers.
● COMMISSION AGENT	An operator of a bulk plant owned by a major oil company.
● INDEPENDENT JOBBER	An owner and operator of one or more bulk plants.
● KEYLOCK SYSTEMS	Self-service pump(s) at a bulk plant.
● MAJOR OIL COMPANY	An integrated corporation which produces, refines and markets petroleum products.
● SUBMERGED FILL	Delivery discharging no more than 15 cm (6 inches) above the tank bottom.
● TANK TRUCK AND TRAILER	Road transportation vehicle for gas.
● SPIT BACK	Transient spillage at gasowner transfer interface.
● OPW	Part number identification for products made by Dover Corporation/OPW Division, Cincinnati, Ohio.
● EMCO WHEATON	Part number identification for products made by Emco Wheaton, Inc., Conneaut, Ohio.

APPENDIX A

INVENTORY OF BULK PLANTS
IN
SAN DIEGO (CALIFORNIA)
SAN JOAQUIN VALLEY (CALIFORNIA)
DENVER (COLORADO)
AIR QUALITY CONTROL REGIONS

TERMINOLOGY OF INVENTORY

PLANT NO.	Arbitrary numerical identification for convenience of relating county data on separate pages.
PLANT IDENTIFICATION	Owner of plant is generally listed first. Operator or brand shown where applicable.
ADDRESS, TELEPHONE NO. AND SOURCE OF INFORMATION	Self explanatory.
FUTURE PLANS	Information on plant expansion or closing, but responses are not complete.
GASOLINE THROUGHPUT	Estimate of maximum daily amount of gasoline sold in gallons per day (converted to liters per day in parenthesis). Response to question, however, was generally given as average daily throughput.
STORAGE TANKS	Location, number and total capacity, in gallons (converted to liters in parenthesis) of gasoline tanks, only.
FLOW RATE	Nominal pump capacity in gallons per minute (converted to liters per minute in parenthesis). This flow is generally identical to outgoing flow rate (same pump).
VAPOR RECOVERY	Presence of incoming balance system.
OUTGOING LOAD	Type of loading rack, presence of balance system, number of trucks and presence of submerged fill for outgoing transfer of gasoline.
CUSTOMERS	Percentage of gasoline throughput to small agricultural accounts (550 gallon tanks of less on farms) and service station accounts. Responses typically indicated few large agricultural accounts.
REMARKS	Other pertinent information given by source.

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF AMADOR

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1. J	Mason Oil Company - David S. Mason	2015 W. Hwy. 88, Martell, CA · 95654	(209) 274-2470	Amador County	
2. J	Don G. Matulich	Rt. 1, Hwy. 49 Plymouth 95669	(209) 245-3482	- - -	Out of Business as of October, 1975

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF AMADOR

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1)x10^{-3}	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
1.	4400 (17K)	A	3	26.75 (100)	- - -	- - -	T	- - -	- - -	Yes	60	40	
2.	- - -	- - -	-	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF CALAVERAS

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1. J	Sierra Petroleum Inc.	P.O. Box 1056 San Andreas 95249	(209) 754-4738	- - - -	
2. A	Standard Oil Keith A. Tallia	Star Route #2 Cement Plant Road San Andreas 95249	(209) 754-4101	Standard Oil and Keith Tallia	
3. A	Ebbetts Pass Gas Service	P.O. Box 6 Arnold 95223	(209) 795-1391	Mrs. Mosdaugh Ebbetts Pass Gas Service	
4. A	Standard Oil K.A. Tallia	Moose Trail Road Angels Camp	(209) 754-4101	Standard Oil and Keith Tallia	Plan to shut down plant, Date unknown

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF CALAVERAS

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1) x 10^{-3}	Flow Rate GPM(1/m	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
1.	- - -	- - -	-	- - - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	
2.	10,000 (38,000)	A	3	30(114)	- - -	No	T	No	4	- - -	30	40	30% Commercial. (Thruput includes plant #4)
3.	1,000 (3,800)	U	4	20(76)	- - -	No	T	No	2	- - -	75	25	
4.	- - -	A	2	39(148)	- - -	No	- - -	No	- - -	- - -	- - -	- - -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF FRESNO

Plant No.	Plant Identification	Address	Telephone No. (209 Area Code	Source of Information	Future Plans
1 J	Haroldsens -Union Oil	1250 Laurel, Kingsburg	897-3114	Mr. Haroldsen	
2 J	Berry's Gas Alley - Arco	735 Manning, Parlier	646-2737	T. Berry	Arco to stop supply on Jan. 1, 1977
3 A	Mobil Oil	796 Fresno, Parlier	646-2727	Mr. Wayne	
4 J	Quinn's Service	1637 7th St., Sanger	875-3423	D. Root	
5 A	Lancaster Union	220 Academy, Sanger	875-3026	Mr. Lancaster	
6 J	Wright Oil	6673 E. S.Fowler St. Fowler	834-2614	J. Wright	
7 A	Std. Oil, McPhail	P.O. Box 301, Auberry	855-2535	McPhail	May close
8 A	Std. Oil, McPhail	Hwy 168, Shaver Lake	841-3223	W.A. Barnard (LA)	
9 J	Rathman Keylock	25561 W. Tuft, Tranquility	698-7458	Rathman	
10 J	J. Silveira-Beacon	5638 S. James, Tranquility	698-5504	R. Marie	
11 J	B. Nachtigall-Beacon	940 I St. Reedly	638-2502	B. Ballow	
12 J	Alta Oil Co.	833 E. Manning, Reedly	638-2645	-	
13 J	W.C. Rhodes - Texaco	392 N. Reed St. Reedly	638-2275	Tony	May close
14 A	Arco- W.H. Kelly	479 Reed St., Reedly	638-3522	Kelly	Closed
15 A	Std. Oil, Heil	609 N. Reed St., Reedly	638-2624	A. Heil	Closing soon
16 J	Wards-Phillips 66	Shaw and Hwy 33, Firebaugh	659-2157	T. Ward	
17 A	Union-Eppler & Cunha	1210 12th St., Firebaugh	659-2189	Cunha	
18 J	Biglione Petroleum	201 Clovis, Clovis	299-6618	Biglione	
19 J	Martin Oil	2205 W. Manning, San Joaquin	693-4665	Martin(486-2770)	
20 A	Union Oil	22050 W. Manning, San Joaquin	693-4482	Mr. Martin	
21 A	Std. Oil	Railroad Av. San Joaquin	693-4601	D. Daly	
22 J	McCraw-Phillips 66	21015 S. Brawley, Riverdale	867-3456	C. McCraw	

J - Jobber
A - Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF FRESNO

Plant No.		Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
23	A	Union Oil - R.C. Hart	3199 W. Mt. Whitney, Riverdale	867-3624	R. Hart	
24	A	Union Oil - R. Lee	W. Elm Ave., Coalinga	935-0826	R. Lee	
25	J	Z. Knight - Phillips	P.O. Box 862, Coalinga	935-0527	Z. Knight	
26	J	J. Lacey - Shell	225 Hayes, Coalinga	935-3116	J. Lacey	
27	J	J. Harness Son-Exxon	Hwy 99 & Floral, Selma	896-0323	J. Harness	
23	J	Darling & Durst	11010 E. Mountain View, Selma	896-1822	-	
29	J	A. Anderson-Phillips	3013 W. Front St., Selma	896-0434	Andersen	May close
30	A	Std. Oil - Guthrie	N. St. & 3rd, Mendota	655-4364	Guthrie	
31	A	Union Oil - Selzi	12525 "H" St., Biola	843-2439	Mr. Selzi	
32	J	A. Dauer- Douglas	4610 N. Biola, Biola	843-2313	D. Dauer	
33	J	Smith Tank Lines	2999 S. Orange, Fresno	266-0116	Mr. Velasquez	
34	J	Hill Oil Co.	2121 S. 3rd St., Fresno	233-7261	F. Dawson	
35	J	Currie Bros.	3217 E. Lorena, Fresno	233-5171	D. McCoy	
36	J	Martin Oil	2874 S. Cherry, Fresno	486-2770	Martin	
37	J	Carey Oil - Mohawk	30 E. Divisidero, Fresno	266-8226	I. Pursell	(Installing Underground tanks)
38	J	Cal-Fresno Oil	2518 S. Railroad Ave., Fresno	233-6211	D. Ruschhaupt	May install underground tanks
39	J	R. Goeringer Dist. Phillips	2414 Monterey, Fresno	233-5137	Mr. Goeringer	
40	A	Texaco	4000 E. California, Fresno	233-2179	A. Chavez	May close
41	J	Seiberts Oil - Beacon	3839 E. Ventura, Fresno	251-7539	Mr. Seibert	

J- Jobber
A- Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF FRESNO

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
42 J	Red Triangle-Gulf	2809 Chestnut, Fresno	485-4320	A. Hohenshelt	
43 A	STD. Oil - Jensen	4073 S. Maple, Fresno	268-4369	Jensen	
44 A	Mobil Oil	333 W. Shaw, Fresno	226-1621	Ans. Service	Plant closed. Del. from Parlier
45 A	Sunland Refining	S. East Ave. & Cal., Fresno	237-7147	G. Gieg	Closing July 1
46 A	Union Oil- Scharff	101 Roosevelt, Fresno	237-5141	Mr. Scharff	Going to underground tanks and bottom loading
47 A	STD Oil - Franks	E. Forest Ave. Coalinga	935-2567	Mr. Franks	May close
48 A	Sunland Refining	667 N. Reed, Reedly	638-2319	Kelly (638-3522)	Closed
49 J	R. Vernon - Shell	210 Academy, Sanger	875-2114	Mr. Vernon	

J - Jobber
A - Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF FRESNO

Plant No.	Gasoline thruput Gal/day(1/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(1)x10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural[(1)]	Service Station	
1	<20,000(<76K)	U	3	44(176)	200(760)	Planned	B	No	2	Yes	80	-	
2	1,000(4K)	A	4	200(760)	-	-	-	-	-	-	95	-	Plan to install underground tan
3	6,000(23K)	A	2	40(151)	100(380)	In Process	B	No	3	Yes	90	-	
4	2,500(9K)	A&U	5	28(106)	-	No	T	No	1	No	95	-	Facility owned
5	5,000(19K)	U	4	48(182)	Dump	Yes	T	No	2	Yes	80	15	Currie Bros.
6	<20,000(<76K)	A&U	5	48(181)	125(470)	No	T	No	1	No	100	-	
7	4,000(15K)	A	3	39(147)	160(600)	Planned	T	No	2	-	80	5	
8	-	A	2	33(125)	-	Yes	-	-	-	-	-	-	
9	<20,000(<76K)	A&U	3	42(163)	90(340)	Planned	T	No	1	Yes	100	0	
10	<20,000(<76K)	A	3	62(234)	100(380)	Yes	T	No	2	-	90	-	
11	6,000(23K)	U	4	40(151)	100(380)	Planned	T	No	1	-	-	-	
12	<20,000(<76K)	A&U	8	40(149)	40(150)	Yes	T	No	2	-	95	-	
13	13,000	A	3	60(227)	250(950)	No	T	No	1	-	30	-	
14	-	A	2	40(151)	-	No	-	-	-	-	-	-	Closed
15	2,000(8K)	A	2	40(151)	120(450)	No	T	No	2	Yes	85	10	
16	7,000 (24K)	A	4	59(223)	(380&760)	No	T	No	4	-	30	-	
17	5,000 (19K)	A	3	50(189)	100(380)	Yes	T	No	2	Yes	20(95)	1	
18	<20,000(<76K)	U	2	20(76)	80(300)	Planned	T	No	2	No	75	-	
19	<20,000(<76K)	U	2	20(76)	75(280)	Planned	T	Planned	1	Yes	90	-	Changing to bottom load
20	4,000 (15K)	A	2	25(95)	60(230)	Yes	T	No	1	No	90	5	Outgoing = 100
21	8,000(30K)	A	4	76(287)	-	Yes	T	No	2	Yes	98	-	
22	2,000(8K)	A	2	48(181)	100(380)	Yes	T	No	3	No	50	-	
23	2,000(8K)	U	3	52(197)	125(470)	Yes	T	No	2	Yes	85	5	Tanks-11 yrs old
24	2,000(8K)	A	3	60(227)	100(380)	Yes	T	No	1	Yes	10(40)	40	
25	<20,000(<76K)	A	3	51(195)	100(380)	No	T	No	1	Yes	90	-	

(1) Nos in parentheses refer to toal agricultural customers (%).

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF FRESNO

Plant No.	Gasoline thruput Gal/day(1/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers -(%)		Remarks
		Above or Under Ground	No.	Total Capacity Gal(1)x10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small(1) Agricultural	Service Station	
26	7,500(28K)	A	3	62(236)	100(380)	Planned	T	No	2	Yes	10	-	
27	<20,000(<76K)	A&U	2	18(68)	-	No	T	No	1	-	95	-	Plan to mod. to self serve
28	<20,000(<76K)	A	6	56(212)	30(110)	No	T	No	1	Yes	100	-	
29	<20,000(<76K)	A	2	61(231)	-	No	T	No	2	-	99	-	Plant built 1916
30	<20,000(<76K)	A	5	72(273)	120(450)	Yes	T	No	2	Yes	5(90)	1	Keylock and bulk plant
31	4,000(15K)	A	3	60(227)	35(130)	Yes	T	No	2	Yes	90	-	
32	10,000(38K)	A&U	4	30(113)	150(570)	No	T	No	1	-	100	-	Ser. Sta & Plant
33	1,000(4K)	U	4	40 (151)	Uses truck	Planned	T	No	1	-	0	-	Outgoing @ 20 GPM
34	<20,000(<76K)	A	6	150(576)	90-200 (340-760)	Yes	T	No	9	Yes	90	-	Plant built in 1912
35	20,000(76K)	A	5	100(380)	600(2,300)	Yes	T	No	6	No	30	-	
36	20,000(76K)	U	8	96(363)	140(530)	Yes	B	Partial	8	Yes	60	-	
37	8,000(30K)	A	7	128(484)	60(230)	Planned	T	No	4	No	-	-	Property is leased
38	10,000(38K)	A	2	30(113)	150(570)	Planned	B	No	3	-	40	20	
39	<20,000(<76K)	A	3	108(408)	-	Yes	T	No	4	Yes	90	-	
40	20,000(76K)	A	5	100(380)	350 (1320)	No	T	No	2	Yes	10	85	
41	<20,000(76K	U	3	30(113)	75(280)	Yes	T	No	1	Yes	30	10	
42	<20,000(<76K)	U	5	76(287)	100&200	Planned	T	No	-	-	10	80	
43	<20,000(<76K)	A	4	80(303)	500&800	Yes	T&B	Partial	4	Yes	75(98)	-	Draws from pipeline and plant
44	-	-	-	-	-	-	-	-	-	-	-	-	Closed

(1) Nos in parenthese refer to total agricultural customers.

		Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers -(%)		
Plant No.	Gaso-line thruput Gal/day(l/d)	Above or Under Ground	No.	Total Capacity Gal(l)x10^3	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
45	5,000(19K)	A	3	52(197)	80-130 (300-490)	No	T	No	1-2	No	60	30	
46	10,000(38K)	A (will be U)	3	60(227)	80(300)	Planned	T (will be B)	Planned	3	Yes	60	10	
47	8,000(30K)	A	3	57(216)	100(380)	No	T	No	-	Yes	40(70)	0	
48	-	-	-	-	-	-	-	-	-	-	-	-	Closed
49	5,000(19K)	A	4	75(289)	-	Yes	T	No	2-3	Yes	60	30	

(1) Nos in parenthese refer to total agricultural customers (%)

-- No data obtained

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1. A	V.H. Blackburn Arco	868 South Derby Road P.O. Box 177 Arvin	(805) 854-2327	Kern County	
2. A	Barulich & Peterson Arco	1040 G Street P.O. Box 843 Wasco 93280	(805) 758-6374	Kern County	
3. A	D.D. Daffern	1441 High Street	(805) 725-0638	Kern County	
4. J	Freeman Chambless	2727 Wear Road P.O. Box 1737 Bakersfield 93302	(805) 589-9583	Kern County F. Chambless	
5. J	H.M. Irwin	2920 Gibson P.O. Box 68 Bakersfield	(805) 399-7407	Kern County	
6. J	James Petroleum Ed Kuhn	1625 Glenwood P.O. Box 151 Bakersfield 93302	(805) 325-7483	Kern County	
7. J	Jeffries Bros. H.B. Jeffries	228 E. Front Street P.O. Box 168 Buttonwillow 93206	(805) 764-5632	Kern County R. Jeffries	
8. J	Jeffries Bros. H.B. Jeffries	Hwy. 46 and Brunning Lost Hills	(805) 797-8347	Kern County	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
9. J	Jeffries Bros. H.B. Jeffries	1224 Hwy. 46 Wesco	(805) 758-3281	Kern County	
10. J	Jeffries Bros. H.B. Jeffries	470 San Joan McFarland	(805) 792-2744	Kern County	
11. J	Kern River Dist. James E. Scott	6505 Wofford Blvd. P.O. Box 97 Wofford Height 93285	(805) 376-2275	Kern County	
12. J	Maple Leaf Pet. Co.	1500 G Street	(805) 758-5131	Kern County	
13. A	Mobil Oil Corp. B.P. #04-443 Curt Pickerfel	4th & Union Bakersfield 93304	(805) 325-6320	Kern County	
14. A	Mobil Oil Corp.	Kernville Rd. & Tobias	- - -	Kern County	
15. A	Mobil Oil Corp. Bulk Plant #04-437 Mr. Marlett	504 Central P.O. Box 1417 Shafter 93263	(805) 745-4451	Kern County	
16. A	Mobil Oil Corp Bulk Plant #04-404 George L. McNiel	Fellows Hwy & Continen Continental P.O. Box 681 Taft 93268	(805) 763-3323	Kern County and G. McNiel	
17. A	Bob Morrasy Union Oil	22581 Est. P.O. Box 7 McKittrick 93251	(805) 762-7301	Kern County and Bob Morrasy	Closing
18. J	Murray Petroleum Douglas C. Murray	4012 Thomas P.O. Box 2331 Bakersfield 93303	(805) 327-5591	Kern County	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
19. J	Navy Oil Co. Joseph E. Jenks	1531 Union Ave. P.O. Box 1147 Bakersfield 93302	(805) 324-6414	Kern County	
20. J	Charles Pence-Douglas	920 East Troxton Ave. Bakersfield 93305	(805) 323-1962	Kern County	Installing Key-Lock System
21. A	Melvin Rufert Arco	815 High Street P.O. Box 668 Delano 93215	(805) 725-8716	Kern County	
22.	F.R. Salsa Texaco	1912 Old Hwy 99 P.O. Box 1089 Delano	(805) 725-9070	Kern County	
23. J	Schwebel Pet. Judith B. Schwebel	900 Sacremento P.O. Box 512 Bakersfield 93302	(805) 324-4061	Kern County	
24. A	Standard Oil Mr. Wood	Bear Mtn. Blvd & Defby Arvin	(805) 325-1600	Kern County and W. Barnard, STD Oil	
25. A	Standard Oil Mr. Gregory	621 High Street Delano	(805) 735-2078	Kern County and W. Barnard, STD Oil	
26. A	Standard Oil Mr. Brudnell	Kern & Lincoln Taft	(805) 763-3061	Brudnell & Kern Co.	
27. A	Standard Oil H.E. Tucker	709 Paso Drive P.O. Box 670 Wasco	(805) 758-6626	Kern County and W. Barnard, STD Oil	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
28. J	Star Petroleum John M. Rogers	16th St. & Q Street P.O. Box 387 Bakersfield 93302	(805) 322-2321	Kern County	
29. A	Union Oil Company Mr. Scaparro	524 Delores Street Bakersfield 93302	(805) 327-5183	Kern County	
30. A	Union Oil Company Mr. Stanley	Valpedo Rd. & Hwy 99 Nettler 93302	(805) 858-2519	Kern County	
31. A	Union Oil Corp. Mr. Brown	216 South 6th Street Taft 93268	(805) 765-5457	Kern County and Mr. Brown	
32. A	Union Oil Corp. Wayne Schulte	527 High Street P.O. Box 906 Delano	(805) 725-1458	Kern County	
33. A	Union Oil Corp.	708 4th Street Wasco 93280	(805) 758-2732	- - -	Closed 3/31/76
34. J	Mike McMillan Sunland Oil	319 Fairhaven Drive P.O. Box 1555 Bakersfield 93302	(805) 372-2061	- - -	No Response.
35.	Belridge Oil	Hwy 33 McKittrick 93251	(805) 762-7311	N. Sutton	Loading rack part of refinery operation.
36.	H. Rollins	P.O. Box 938 Mojave 93501	(805) 824-4250	- - -	Not in San Joaquin Valley AQCR

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
37.	W.R. Letlon James Petroleum	1625 Glenwood P.O. Box 636 Delano 93215	(805) 725-0268	- - -	Bulk Plant operated by James Petroleum in Bakersfield (see Plant #6). No Bulk plant at this location.
38. J	Jouis H. Seay Phillips Pet	P.O. Box N Fellows 93224	(805) 768-4581	Louis H. Seay	
39.	Grapevine Oil Co. Union Oil	P.O. Box 2353 Bakersfield 93303	(805) 327-2903	- - -	Gasoline Station only
40.	Douglas-Davies	3305 Gulf	(805) 325-1261	Davies	Diesel only
41. A	STD Oil - Henry	Sierra Way, Kernville	(714) 376-2643	W. Barnard (STD oil)	
42. A	STD Oil - Sullivan	Mano & Norris Road Bakersfield	(805) 393-1312	W. Barnard (STD oil)	Bulk Plant & Refinery Terminal

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

Plant No.	Gasoline Thruput Gal/day(1/d)	Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal.(1)x10-3	Flow Rate GPM(1/m	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1.	4,000(15K)	A	2	40 (151)	- - -	Yes	- -	- - -	3	- -	- - -	- - -	
2.	3,000(11K)	A	2	41.6(157)	- - -	Yes	- -	- - -	2	- -	- - -	- - -	
3.	1,500(5.7K)	- - - -	-	- - - - -	- - -	- - -	- -	- - -	1	- -	- - -	- - -	
4.	2,500(9.5K)	A	2	40 (151)	60	Yes	T	No	2	- -	20	- - -	
5.	1,300(4.9K)	A	1	0.550(2.1)	- - -	No	- -	- - -	2	- -	- - -	- - -	
6.	2,500(9.5K)	A	3	36 (136)	- - -	Yes	- -	- - -	2	- -	- - -	- - -	
7.	2,500(9.5K)	A	3	19.5(73.8)	100	Yes	T	No	2	Yes	75	- - -	
8.	1,000(3.8K)	U	3	28 (106)	- - -	- - -	T	- - -	1	Yes	- - -	- - -	
9.	4,000(15K)	U	3	24 (90)	- - -	- - -	T	- - -	3	Yes	- - -	- - -	
10.	2,500(9.5K)	A	3	19.5(73.8)	- - -	- - -	T	- - -	2	Yes	- - -	- - -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
t No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1) × 10^{-3}	Flow Rate GPM(1/m	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
1.	1,000(3.8K)	U	2	20 (76)	- -	- - -	- -	- - -	1	- -	- - -	- - -	
2.	5,000(19K)	A	4	46.8(177)	- -	Yes	- -	- - -	2	Yes	- - -	- - -	
	Confid.	A	2	45 (170)	- -	Yes	- -	- - -	2	- -	- - -	- - -	
4.	Confid.	U	2	20 (76)	- -	Yes	- -	- - -	1	- -	- - -	- - -	
5.	Confid.	U	2	20 (76)	- -	Yes	- -	- - -	3	- -	- - -	- - -	
6.	5,000(19K)	A	2	40 (151)	130	Yes	T	No	2	Yes	- - -	- - -	
7.	2,000(7.6K)	A	2	40 (151)	- -	No	T	No	2	Yes	- - -	- - -	
8.	1,000(3.8K)	U	3	26 (98)	- -	- - -	T	- - -	1	Yes	- - -	- - -	
9.	9,000(34K)	U	3	33 (125)	- -	- - -	- -	- - -	4	- -	- - -	- - -	Installing new venting systems for storage tanks
0.	3,000(11K)		3	26.5(100)	- -	- - -	- -	- - -	2	- -	- - -	- - -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
ant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1) x 10⁻³	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
21.	3,000(11K)	A	2	40 (151)	- -	Yes	- -	- -	1	- -	- -	- -	
22.	5,500(21K)	A	2	40 (151)	- -	- - -	- -	- -	2	- -	- -	- -	
23.	9,500(36K)	- - -	-	- - - - - -	- -	- - -	- -	- -	4	- -	- -	- -	
24.	5,500(21K)	A	4	64.7 (245)	- -	Yes	- -	- -	4	- -	- -	- -	
25.	4,000(15K)	A	4	80 (303)	- -	Yes	- -	- -	2	- -	- -	- -	
26.	4,000(15K)	A	3	53 (201)	80	Yes	T	No	2	- -	90	- -	
27.	2,000(7.6K)	A	3	43 (163)	- -	Yes	- -	- -	2	- -	- -	- -	
28.	5,500(21K)	A	3	60 (227)	- -	Yes	- -	- -	2	- -	- -	- -	
29.	4,000(15K)	U	3	60 (227)	- -	Yes	- -	- -	2	- -	- -	- -	
30.	2,500(o.5K)	A	2	40 (151)	- -	Yes	- -	- -	2	- -	- -	- -	
31	3,000(11K)	A	2	40 (151)	150	Yes	T	No	2	Yes	- -	- -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KERN

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacitv Gal.(1) x 10^{-3}	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
32.	4,000(15K)	A	3	60 (227)	- -	- - -	- -	- - -	2	- -	- - -	- -	
33.	3,500(13K)	- - -	-	- - - - - -	- -	- - -	- -	- - -	- -	- -	- - -	- -	
38.	1,000(3.8K)	A	2	26 (98)	100	- - -	T	No	1	No	10	- -	
41.	- - - -	A	3	48.7 (184)	- -	Yes	- -	- - -	- -	- -	- - -	- -	
42.	- - - -	A	2	32.5 (123)	- -	Yes	- -	- - -	- -	- -	- - -	- -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KINGS

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
-	ARCO - William P. Roe (A)	9190 Lacey Blvd. Hanford	(209) 584-5690	Kings Co.	
-	Beacon Oil - C.F. Archer	Whitely, Corcoran		Kings Co.	
-	Mobil Oil - M.H. Archer	504 Sherman, Corcoran	(209) 992-3515	Kings Co.	
-	Mobil Oil - Ross Butler	10th Ave & 5th, Hanford	(209) 582-0221	Kings Co.	
-	Mohawk (Central Valley Coop) - Don Webber	9845 Hanford-Armona Rd. Hanford	(209) 582-0321 582-0258	Kings Co.	
-	Union - Gene Bowman (A)	1130 Pickerel, Corcoran	(209) 992-4161	Kings Co.	
-	Standard Oil - Gary Burrows (A)	So. Pickerel, Corcoran	(209) 992,2218	Kings Co.	
-	Standard Oil - Gary Burrows (A)	416 N. Lemoore, Lemoore	(209) 924-2064	Kings Co.	
-	Standard Oil - Bill Franks (A)	Kettleman Hills, Avenal	(209) 386-9443	Kings Co.	
-	Sunland Oil - Tom Dowd (A)	533 S. Williams, Hanford	(209) 584-8830	Kings Co.	No info received
-	Texaco - Mr. Buford	9925 8 3/4 Ave. Hanford	(209) 582-9028	Kings Co.	

(Locations are just listed on this page. Plant data numbered on the next pages do not correspond to this list. County gave data so correlation would not be made between particular location and data.)

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF KINGS

Plant No.	Gasoline Thruput Gal/day(1/d)	Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal.(1) x 10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1.	3175(12K)	A	2	32 (121)	- - -	- - -	T	- -	3	Yes	80	10	10% Commercial
2.	2380(9K)	U	4	41.5(157)	- - -	- - -	T	- -	2	- -	60	30	10% Commercial
3.	6125(23K)	A	5	80.7(305)	- - -	- - -	T	No	4	- -	75	1	24% Commercial
4.	860(3K)	A	3	50. (189)	- - -	- - -	T	No	1	- -	75	-	25% Commercial
5.	1490(6K)	A	2	38.8(147)	- - -	- - -	T	- -	1	- -	80	10	10% Commercial
6.	3575(14K)	A	3	26. (98)	- - -	- - -	T	- -	2	- -	99	-	
7.	3765(14K)	A	2	30 (114)	- - -	- - -	T	- -	2		85	13	2% Commercial
8.	2000(8K)	A	5	50 (189)	- - -	- - -	T	- -	4	- -	87	13	
9.	- - - -	A	2	28 (106)	- - -	- - -	T	- -	1	- -	20	- -	80% Commercial
10.	- - - -	A	4	59.5(225)	- - -	- - -	- - -	No	- -	- -	- -	- -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF MADERA

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1 A	Sunland - A. Bianchi	25121 Ave. 12 1/2 Madera	(209) 674-4215	A. Bianchi	May shut down
2 A	Mobil Oil - H. Cook & L. Tesei	929 S. "E" St. Madera	(209) 673-3597	H. Cook	
3 J	I.M. McCulley -Shell	505 S. Gateway, Madera	(209) 674-4993	Mr. McCulley	
4 J	Phillips - Archibald	631 S. Gateway, Madera	(209) 674-7037	Mr. Archibald	
5 J	Martinoil	13876 Hw 99, Madera	(209) 674-4391	Mr. Martin (486-2770)	
6 A	Texaco - E. Bispham	Olive & E. 14th St. Madera	(209) 673-9168	Mr. E. Bispham	
7 J	Currie Bros. Inc. Exxon	2001 Howard Rd. Madera	(209) 674-5568	Mr. McCoy (233-5171)	
8	Beacon Dist.	373 S. Chowchilla Bl. Chowchilla	(209) 665-4884	-	
9 A	Std Oil - Myers & Dean	27348 Ave. 14, Madera	(209) 673-3101	Mr. Myers	
10 A	Std Oil - Bob Dean	Gen. Delivery, Coarse Gold	(209) 683-4418	Mr. Dean	May close
11 A	Std Oil - Henderson	115 S. Chowchilla, Chowchilla	(209) 665-3242	Mr. Henderson	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF MADERA

Plant No.	Gaso-line thruput Gal/day(1/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(1)x10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	4000(15K)	U	2	28(106)	35(130)	No	T	No	2	-	40	50	Tanks installed in 1958
2	10000(38K)	A	2	42(159)	150(570	No	T	No	2	Yes	90	5	
3	<20000(<76K	A	3	75(284)	300(1140	No	T	No	2	Yes	40	60	Tanks are 30 yrs old
4	2000(8K)	A	2	34(129)	100(380	No	T	No	1	Yes	30	-	
5	<20000(<76K	U	3	36(136)	40(150)	No	T	No	Varies	-	90	-	
6	3000(11K)	A	3	52(197)	100(380	No	T	No	1	Yes	35	40	
7	<20000(<76K	U	4	48(182)	200(760	No	T	No	1	No	55	-	
8	5000(19K)	A	3	26(98)	100(380	No	T	No	2	Yes	98	-	
9	<20000(<76K	A	2	38(144)	180(680	No	T	No	2	-	90	0	
10	10000(38K)	A	2	40(152)	80(300)	No	T	No	2	Yes	97	-	
11	4000(15K)	A	3	53(201)	100(380	No	T	No	2	Yes	99	-	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF MARIPOSA

Plant No.	Plant Identification	Address	Telephone No. (209) Area Code	Source of Information	Future Plans
1 J	Ira Chase - Texaco	Hwy. 49 & Ben Hur Road, Mariposa	966-3314	Mr. Ira Chase	
2 A	H. L. Odger-Standard Oil	El Portal Rd., El Portal	379-2621	Mr. Odger	
3 A	J. A. Martin-Union	Hwy. 140, Mariposa	966-2488	Mr. Martin	

J - Jobber
A - Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF MARIPOSA

Plant No.	Gasoline thruput Gal/day(1/d)	Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal.(1)x10^{-3}	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	5,000 (19K)	U	3	31(117)	200(760)	No	T	No	2	--	60	30	
2	1,000 (4K)	A	3	63(238)	140(530)	No	T	No	2	Yes	90	5	Gravity Load Trucks
3	4,000 (15K)	U	3	30(113)	Dump	Probably	Nozzle at top	No	2	No	75	5	Outgoing-100 GPM

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF MERCED

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1	Lyon Oil - D.A. Stiles	16th & 6th Streets, Merced	(209) 722-9202	D.A. Stiles & Mr. Heights	Closing
2	Farmers Oil (Douglas)	385 S.Hwy 59, Merced	(209) 722-6645	Gary Parsons	
3	Texaco-A.W. Laughton	863 W. 15th, Merced	(209) 722-4203	A.W. Laughton	
4	Val's Beacon	Beachwood & Ashby, Merced	(209) 722-4611	Mr. Valentine	
5	Mobil - Mel Koontz	15th & H. Streets, Merced	(209) 722-9052	Mr. Koontz	
6	Thurman Distributors	W 15th & I Sts., Merced	(209) 722-6055	Mr. Thurman	
7	Valley Oil -Leonard Tank Lines - Mohawk	625 J St. Merced	(209) 722-4171	Mr. Coffee	
8	Exxon-F.H. Silveira	2145 Atwater Blvd. Atwater	(209) 723-2461	Mrs. Silveira	
9	At. Richfield - L.C. Jirsa	W 16th & T St. Merced	(209) 723-3811	Mr. Bud Jirsa	Plant closed - hauls direct
10	Std. Oil - Bartlett	15th & G St. Merced	(209) 722-9422	Mr. Barlett	
11	Union - D.M. Seals	1590 16th St. Merced	(209) 722-7096	D.M. Seals	
12	Becker Oil - Lyon	1330 Pacheco Blvd. Los Banos	(209) 826-4528	Mr. Becker	
13	Std. Oil	H & 9th St., Los Banos	(209) 826-5658	Mr. Windecker	
14	Pacheco Oil Co.	1704 Pacheco, Los Banos	(209) 826-3794	Mr. F. Santos	
15	Union Oil	101 H St. Los Banos	(209) 826-2236	Mr. G. Barrington	
16	Wesco Oil	1893 N. Hwy 33, Gustine	(209) 854-3143	Mr. Bill Noble	
17	Currie Bros.	46113 W. Valeria, Dos Palos (Wrong address)*	(209) 233-5171	Mr. R. McCoy	Not in County
18	Mobil	2801 Blossom, Dos Palos	(209) 392-2627	Mr. J. Nicoletti	
19	ARCO - Latorraca	Hwy 152 & Island Rd. Dos Palos	(209) 387-4380	Mr. Latorraca	
20	DosPalos Y Equipment	2857 Blossom, Dos Palos	(805) 589-9615	Mr. Morin	
21	Std. Oil	1822 C, Livingston	(209) 394-2611	Mr. W. Rasmussen	Plant closed - loads in Turlock
22	Lyon Oil-V. Broadway	9th & H St., Los Banos	- - - - -	- - - - -	Closed

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF MERCED

Plant No.	Gaso-line thruput Gal/day(l/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(l)x10^3	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	3500(13K)*	A	3	75(284)	100(380)		T	No	2	No*	75	15	Closing
2	4000(15K)*	U	3	28(106)	Dump	Yes	T	No	1	No*	90	20	Service Sta. & Bulk Plant
3	4000(15K)*	U	3	36(136)	Dump	Yes	T	No	2	Yes	50	50*	Outflow = 80GPM
4	5000(19K)*	U*	3	39(148)	Dump	Planned	T	No	2	No	50	25*	Service St. & Bulk Plant
5	5000(19K)	A	2	40(151)	150(570)	Yes	T	No	1	No	60	0	
6	6000(23K)*	A	3	60(227)	300	Planned	T	No	2	No	40	40	Built in 1948
7	6000(23K)	A	3	60(227)	75(280)	Yes	T	No	2	No	75	20	
8	8000(30K)	U	3	42(159)	-	Yes	T	No	3	No	50	25	
9	8000(30K)*	A	2	40(151)	-	-	-	-	-	No	-	-	
10	12000(45K)*	* A	6	120(454)	250(950)	Yes	T	No	3	Yes	50	15	Includes Aviation gas
11	12000(45K)	U	3	44(166)	150&200 (570)& (760)	Yes	B	Yes	4	Yes	90	5	
12	5000(19K)	A	3	44(166)	100(380)	Yes	T	No	2	No	90	10	
13	8000(30K)	A	4	70(265)	120(450)	Yes	T	No	2	Yes	85	0	
14	6000(23K)	A	2	50(189)	100(380)	Yes	T	No	1	No	90	0	Built in 1930's
15	8000(30K)	U	3	44(166)	130(490)	Yes	B	Yes	4	Yes	80	10	Keylock & Bulk Plant
16	5000(19K)	A	4	64(242)	200(760)	Yes	T	No	1	No	85	15	Built in 1932
17	<20000(<76K)	A	4	48(182)	200(760)	No	T	No	1	No	85	-	Not in County*
18	10000(38K)	A	3	63(238)	150(570)	Yes	T	No	3	No	70	25	
19	2000(8K)*	A	2	20(76)	32(120)	No	T	No	1	No*	90	0	
20	<20000(<76K)	A	3	60(227)	-	Yes	T	No	-	No	90	0	
21	-	-	-	-	-	-	-	-	-	-	-	-	Closed
22	2500(9K)*	A	3	40(151)	-	-	-	-	-	-	90	10	Closed

*Data corrections by Merced County

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN JOAQUIN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1.	ARCO	P.O. Box 871 Manteca 95336	- - - - -	San Joaquin County	Plant Shut Down March 1976
2. A	ARCO	Lodi	- - - - -	San Joaquin County	Will be sold as of July 1976.
3.	Reuben Baumbach, Douglas Oil Co.	900 S. Cherokee Lodi	(209) 369-8019	San Joaquin County	
4. J	J.A. Busalacchi	946 W. Oak Stockton	(209) 462-7665	San Joaquin County	
5. J	L & M Petroleum Roy H. Leabo	45 N. Harrison Street Stockton	(209) 466-8035	San Joaquin County	
6. J	Moore Petroleum Jerry L. Moore	P.O. Box 67 Banta	(209) 835-2750	San Joaquin County	
7. J	Johnston Oil Co. Richard Johnston	P.O. Box 131 Tracy	(209) 835-3876	San Joaquin County	
8. J	Pete Smith Jobber Shell Products	Port Road 21 Stockton	(209) 464-4886	San Joaquin County	
9. A	Standard Oil R.L. Wilcox	580 E. Lockford	- - - - -	San Joaquin County	
10. A	Standard Oil J.H. Wright	1512 Weiss Way	(209) 838-7935	San Joaquin County	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN JOAQUIN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
11. A	Sunland Oil Co. Jay McIlrath	3025 Navy Drive Stockton	(209) 462-8707	San Joaquin County	
12.	Union Oil Co. M.F. Pimentiel	8203 W. Hwy 50 Tracy	(209) 835-1643	San Joaquin County	
13.	Union Oil Bob Sivell	609 Victor Road Lodi	(209) 368-0192	San Joaquin County	
14.	Mobil Oil Mr. John Broggie	E. Grant Line Road Tracy 95376	- - - - -	- - - - -	No Response
15.	Mobil Oil Mr. Ed Pribble	838 E. Mokelumne Woodbridge 95258	- - - - -	- - - - -	No Response
16. J	Mr. Marvin Dinkle Shell Oil Jobber	P.O. Box 610 South Tracy Blvd. Tracy 95376	- - - - -	- - - - -	No Response
17. J	Jim Thorpe	321 N. Beckman Road Lodi 95240	- - - - -	- - - - -	No Response
18. J	Delta Stations	3005 Navy Drive Stockton 95201	- - - - -	- - - - -	No Data
19. A	Standard Oil D.A. Woolsey	P.O. Box 37 Kasson Rd. & Hwy 50 Banta 95368	- - - - -	- - - - -	No Data

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN JOAQUIN

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
20. J	George W. Lowry	P.O. Box 176 Salida 95368	- - - - -	- - - - -	No Data
21. J	Major Oil Co. Gulf Distributor	4509 Pacific Ave. Stockton 95207	- - - - -	- - - - -	No Data
22.	Ridon Farm Service	P.O. Box 786 Ridon 95366	- - - - -	- - - - -	No Data

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN JOAQUIN

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1)x10-3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
3.	2,000 (10.6K)	U	4	80 (303)	- - -	No	T	No	1	No	31	9	Total Ag. Accounts 91%
4.	800 (3.0K)	- - -	-	- - - -	- - -	- - -	- - -	- - -	- -	- -	- - -	- -	No Bulk Plant. Just Gas delivering service.
5.	2,900 (11.0K)	A	2	57.1(216)	- - -	No	T	No	2	No	10	50	Total Ag. 50%
6.	4,000 (15.1K)	A	4	37.5(142)	- - -	No	T	No	3	Yes	3	19	Total Ag. 81%
7.	2,500 (9.5K)	A	3	32 (121)	- - -	Yes	T	No	3	Yes	16	28	Total Ag. 72%
8.	3,400 (13.1K)	U & A	2 & 1	28.2(107)	- - -	- - -	T & B	- - -	3	Yes	0.5	91	Total Ag. 9%
9.	5,900 (22.4K)	A	3	55.9(212)	- - -	Yes	- - -	No	- -	Yes	- - -	- -	
10.	4,200 (15.7K)	A	2	39 (148)	- - -	No	- - -	No	- -	Yes	- - -	- -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN JOAQUIN

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1)x10^{-3}	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
11.	1,200 (4.4K)	- - -	-	- - - -	- -	- -	T	No	1	Yes	30	27	Total Ag. 73%
12.	3,300 (12.5K)	A	3	60(227)	- -	No	T	No	2	Yes	2	29	Total Ag. 71%
A 13.	3,000 (11.2K)	U	2	32(121)	- -	- -	B	No	1	- -	0	100	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF STANISLAUS

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1. J	A.J. Agostini	532 N. Sierra Ave. P.O. Box 455 Oakdale 95361	- - - - -	Stanislaus County	
2. J	Barrington And Barrington	P.O. Box 608 Newman 95360	- - - - -	Stanislaus County	
3. J	Charles Bettencourt	P.O. Box 1112 632 9th Street Turlock	- - - - -	Stanislaus County	
4. A	W.H. Breshears Standard Oil	721 B Street Modesto	(209) 522-7291	Stanislaus County & W. Barnard (STD Oil)	
5. A	Charles L. Bryant Union Oil	920 Virginia Ave. Modesto	(209) 529-3030	Stanislaus County	
6. J	Arlet Dickey	630 Golden State Blvd. Turlock	- - - - -	Stanislaus County	
7. J	Joe M. Gomes Phillips Pet.	1716 South Paulson P.O. Box 926 Turlock	(209) 634-3723	Stanislaus County	
8. J	Goodwin Oil Co.	P.O. Drawer 369 Turlock	- - - - -	Stanislaus County	
9. A	John Hodges Union Oil	P.O. Box 36 Westley 95387	- - - - -	Stanislaus County	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF STANISLAUS

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
10.	Will Inselman - Texaco	3460 El Camino, Ceres	(209) 537-4703	Stanislaus County	
11. A	STD, Oil - Harry E. Johnston	1124 N. Front Street Turlock	- - - - - -	Stanislaus County & W. Barnard (STD, Oil)	
12. J	George W. Lowry	4612 Kiernan Salida	(209) 545-0791	Stanislaus County	
13.	W.G. McDowell Mobil Oil	1249 Woodland Ave. P.O. Box 1248 Modesto 95353	- - - - - -	Stanislaus County	
14. J	Mid County Distributors Phillipe Pet. Ken Bardsley	102 North 9th Street P.O. Box 3686 Modesto	(209) 522-9067	Stanislaus County	
15. J	George H. Nunes	Hwy 99 P.O. Box 578 Keyes 95328	(209) 632-1056	Stanislaus County	
16. J	Parros & English	511 South 2nd Street Patterson 95363	(209) 892-8902	Stanislaus County	
17. J	G.W. Paul and Son Shell Products	P.O. Box 237 Oakdale 95361	(209) 847-2068	Stanislaus County	
18.	Alfred Rose Jr. Mobil Oil	746 Merced P.O. Box 567 Newman 95360	(209) 862-3736	Stanislaus County	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF STANISLAUS

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
19.	Clark Saunders Arco	P.O. Box 977 Turlock 95380	(209) 634-4452	Stanislaus County	
20. A	J.M. Titchenal Standard Oil	P.O. Box 248 Oakdale	- - - - -	Stanislaus County	
21. J.	Donald J. Vieira	P.O. Box 1298 Patterson 95363	- - - - -	Stanislaus County	
22. J	E.R. Vine & Sons Exxon	2825 Railroad Ave. P.O. Box 276 Ceres 95307	(209) 537-0723	Stanislaus County	
23.	Henry J. Weiss Union Oil	1000 N. Front Street P.O. Box 767 Turlock 95380	(209) 634-1175	Stanislaus County	
24. J	Paul Wenstrond	4148 Main Street Denair 95316	(209) 634-5720	Stanislaus County	
25. A	Stan Boyett & Sons ARCO	9th & Needham P.O. Box 3896 Modesto 95352	(209) 545-1122	Stan Boyett	Closed May 7, 1976.
26. J	Stuart & Hebert Phillips Pet.	P.O. Box 851 Modesto 95353	- - - - -	- - - - -	No Bulk Facility. Get gasoline from Mid County Distributors (see Plant #14)

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF STANISLAUS

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - % Calculated on Tanks Served Less Than 550 G		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1)x10^{-3}	Flow Rate GPM(1/m)	Vapor Recov-ery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricul-tural	Service Station	Remarks
1.	10,000(38K)	A	2	38 (144)	--	---	--	--	-	--	87	3	Total Ag. 97%
2.	10,000(38K)	A	2	32 (121)	--	---	--	--	-	--	54	12.5	Total Ag. 87.5%
3.	----	---	7	60 (227)	--	---	--	--	-	--	98	0	Total Ag. 100%.
4.	11,000(42K)	A	5	100 (379)	--	Yes	--	--	-	--	39	23	Total Ag. 77%
5.	8,500(32K)	A	3	61.4(232)	--	---	--	--	-	--	44	23	Total Ag. 77%
6.	6,000(23K)	A	2	40 (151)	--	---	--	--	-	--	34	6	Total Ag. 94%
7.	7,300(28K)	A	3	30 (114)	--	---	--	--	-	--	86	12	Total Ag. 88%
8.	4,000(15K)	3 A 1 u	4	60.5(229)	--	---	--	--	-	--	25	62.5	Total Ag. 37.5%

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SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF STANISLAUS

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - % (Less Than 550 G)		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1)x10^{-3}	Flow Rate GPM(1/m)	Vapor Recov-ery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricul-tural	Service Station	Remarks
9.	2,500(9K)	U	3	27 (102)	- -	- - -	- -	- -	-	- -	83	0	Total Ag. 100%
10.	12,000(45K)	A	3	37.5(142)	- -	- - -	- -	- -	-	- -	58	33	Total Ag. 67%
11.	9,090(34.4K)	A	5	91 (344)	- -	Yes	- -	- -	-	- -	69	24	Total Ag. 76%
12.													(All gasoline obtained from plant #13)
13.	10,434(39.5K)	A	3	60 (227)	- -	- - -	- -	- -	-	- -	46	19	Total Ag. 81%
14.	15,000(57K)	A	4	70 (265)	- -	- - -	- -	- -	-	- -	34	5	Total Ag. 95%
15.	2,500(9.5K)	1 A 1 U	2	24 (91K)	- -	- - -	- -	- -	-	- -	95	4	Total Ag. 96%
16.	18,741(70.9K)	6 A 4 U	10	90.5(343)	- -	- - -	- -	- -	-	- -	37	19	Total Ag. 81%
17.	23,000(81K)	A	3	62.5(237)	- -	- - -	- -	- -	-	- -	67	28	Total Ag. 72%

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF STANISLAUS

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - % (Less Than 550 G)		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1) x10^{-3}	Flow Rate GPM(1/m)	Vapor Recov-ery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricul-tural	Service Station	Remarks
18.	8,000(30K)	5 A 2 U	7	63.5(240)	- -	- - -	- -	- -	-	- -	77	12	Total Ag. 88%
19.	3,500(13.2K)	A	4	55.5 (210)	- -	- - -	- -	- -	-	- -	54	26	Total Ag. 74%
20.	1,236(4679)	A	4	71.4(270)	- -	- - -	- -	- -	-	- -	73	9	Total Ag. 91%
21.		A	2	34.1(129)	- -	- - -	- -	- -	-	- -	80	9	Total Ag. 91%
22.	18,500(70K)	U	5	57 (216)	- -	- - -	- -	- -	-	- -	58	18	Total Ag. 82%
A 23.	9,275 (35,110)	A	3	60 (227)	- -	Yes	B	Yes	2	- -	53	18	Total Ag. 82%
24.	2,000(7.6)	A	3	15 (57)	- -	- - -	- -	- -	-	- -	98	0	Total Ag. 100%

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF TULARE

Plant No.		Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1	A	Mobil-Dinkins	720 S. Main, Porterville	(209)784-4051	C. Riggins	
2	J	R. Havens - Shell	336 S. "E" St. Porterville	(209)784-3017	R. Havens	
3	J	James Petroleum - Phillips	286 S. "E" St. Porterville	(209)784-1089	Tim Buyers	
4	J	J. Griggs	73 W. Vine, Porterville	(209)784-4715	F. Ross(592-3152)	
5	A	ARCO - J.L. Davies	358 S. "E" St. Porterville	(209)784-6580	J. Davies	ARCO may close
6	A	Texaco	1061 N. Main, Porterville	(209)784-2384	T. Callison	
7	J	Gifford, Inc. - Shell	250 W. Lindmor, Lindsay	(209)562-3072	Gifford	
8	J	Purmax Oil Co.	1430 S. Mirage, Lindsay	(209)562-3513	J. Perkes	
9	J	Orange Belt & Supply	635 Blue Gum, Lindsay	(209)562-2574	B. Graves	
10	J	J. Griggs	1149 S. Kaweah, Exeter	(209)592-3154	F. Ross	
11	J	D. Rose - Shell	205 Ben Maddox Way, Visalia	(209)733-4717	Ballanger	
12	A	Beacon Dist.	2001 E. Mineral King, Visalia	(209)734-5878	J. McCutchen (582-0241)	
13	J	Julien Oil Co. - Phillips	1319 W. Goshen, Visalia	(209)732-2151	Weathery	Changing to underground tanks
14	A	Union Oil	1821 W. Tulare, Visalia	(209)734-4634	J. Landsdown	
15	J	Std Oil - J.A.Fischer	1633 E. Mineral King, Visalia	(209)732-8381	J. Fischer	
16	A	Mobil Oil	518 S. Lovers Lane, Visalia	(209)732-3122	Mr. Wallace	
17	J	C.P. Phelps - Exxon	196 W. Klindera, Tipton	(209)752-4013	Phil Santos (686-1591)	
18	J	C.P. Phelps - Exxon	1010 S. Blackstone, Tulare	(209)686-1591	Phil Santos	
19	J	Orange Belt & Supply	515 W. Naranjo, Woodlake	(209)562-2574	B. Graves (Lindsay)	
20	A	Sunland Ref. Corp.	575 S. "K" St. Tulare	(209)686-5837	Mr. Morin (805/589-9615)	
21	J	J. Harness & Son - Exxon	1150 E. El Monte, Dinuba	(209)896-0323	J. Harness	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF TULARE (cont)

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
22 A	Union	100 W. Bardsley, Tulare	(209)686-5162	L. Cadona	
23 J	E.D. Tait - Beacon	601 Front St. Pixley	(209)757-3203	E. Tait	
24 A	Sunland Ref. Corp.	33247 Road 156, Ivanhoe	(209)798-1121	Morin (805/589-9615)	
25 J	E.B. Johnstone - Shell	501 S. "M" St. Dinuba	(209)591-4460	E. Johnstone	
26 A	Union Oil Dist. - Collins	358 W. El Monte, Dinuba	(209)591-2861	B. Collins	
27 J	D.F. Davis - Shell	100 S. Valencia, Woodlake	(209)564-8921	D. Davis	
28 A	Mobil Oil	Palm & El Monte, Orosi	(209)732-3122	Mr. Wallace	
29 A	Mobil Oil	517 S. Main, Pixley	(209)757-3556	Would not give name	
30 A	Union Oil	682 S. Main, Porterville	(209)784-7600	L. Cadona	Closed - delivery now from Tulare
31 A	Agristruction	Ave. 413 & Rd. 124, Orosi	(209)528-4077	Gary Hayes	Diesel only
32 A	Std Oil - Taylor	11 E. Yates Ave, Porterville	(209)784-2184	B. Taylor	
33 A	Mobil Oil - Quinn	2052 No. J. Tulare	(209)686-6353	D. Quinn	
34	Atlantic-Richfield Oil	1214 E. Main, Visalia	(209)732-8625	Fischer (732-8381)	Closed

J - Jobber
A - Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF TULARE

Plant No.	Gaso-line thruput Gal/day(1/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(1)x10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	11000(42K)	A	2	43(162)	130(490)	Yes	T	No	2	Yes	85	-	
2	10000(38K)	A	3	75(283)	100(380)	Planned	T	No	2	No	20	-	
3	5000(19K)	A	3	51(193)	100(380)	Yes	T	No	1	No	95	-	
4	<20000(<76K)	U	3	30(113)	-	No	T	No	1	Yes	99	-	
5	5000(19K)	A	2	32(121)	150(570)	Yes	T	No	2	Yes	95	1	ARCO may close
6	20000(76K)	A	3	60(227)	220(830)	Planned	T	No	3	Yes	50	25	
7	4000(15K)	U	2	10(38)	100(380)	Yes	T	No	4	Yes	50	10	
8	4000(15K)	U & A	6	22(83)	50(190)	Yes	T	No	3	No	-	-	
9	4000(15K)	U	2	24(91)	150(570)	Yes	T	No	1	Yes	-	-	
10	7000(26K)	U	6	48(182)	100(380)	Yes	T	No	1	Yes	99	-	
11	<20000(<76K)	A	2	50(189)	100(380)	No	T	No	3	Yes	90	-	
12	<20000(<76K)	U	3	32(121)	100(380)	Yes	T	No	2	Yes	90	-	Each delivery now requires 15 min. more
13	15000(57K)	A	3	142(537)	180(680)	Yes	T	No	4	Yes	90	-	
14	10000(38K)	U	5	48(181)	Dump	Yes	T	No	2	Yes	80	7	Outgoing = 80GPM
15	>20000(>76K)	U	6	96(362)	Dump	Yes	B	Yes	8	Yes	80	1	Outgoing =200GPM
16	5000(19K)	U	4	50(189)	Dump	Yes	T	No	1	No	60	30	
17	2000(8K)	U	3	30(113)	100(380)	Yes	T	No	2	Yes	60	-	
18	3000(11K)	U	3	30(113)	100(380)	Yes	T	No	2	Yes	60	-	
19	4000(15K)	A	4	24(91)	150(570)	Yes	T	No	1	Yes	-	-	
20	<20000(<76K)	A	3	60(227)	-	-	-	-	-	-	20		
21	<20000(<76K)	U	3	21(79)	-	Yes	T	Yes	1	-	85	-	
22	8000(30K)	A	3	58(219)	70(265)	Yes	T	No	4	Yes	95	0	Plan underground in November
23	2000(8K)	U	2	17(63)	Dump	Planned	T	No	2	No	99	1	Outgoing = 60GPM
24	<20000(<76K)	A	3	60(227)	-	-	-	-	-	-	20	-	
25	12000(45K)	A	3	70(265)	100(380)	Not yet	T	No	2	Yes	30	70	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF TULARE (cont)

Plant No.	Gaso-line thruput Gal/day(1/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(1)x10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
26	6000(23K)	A	3	60(227)	-	Yes	T	No	3	Yes	80	5	
27	4000(15K)	A	2	50(189)	100(380)	Not yet	T	No	2	Yes	90	10	
28	1500(6K)	U	2	20(76)	Dump	Yes	T	No	1	No	60	30	Outgoing at 100 GPM
29	<20000(<76K)	U	3	30(113)	Dump	Yes	T	No	1	Yes	99	-	Outgoing at 60 GPM
30	-	-	-	-	-	-	-	-	-	-	-	-	
31	-	-	-	-	-	-	-	-	-	-	-	-	
32	6000(23K)	A	3	58(218)	60(230)	Yes	T	No	2	Yes	90	1	
33	6000(23K)	A	3	60(227)	100(380)	Not yet	T	No	2	Yes	80	15	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF TUOLUMNE

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1. A	Standard Oil M.C. Dawson	P.O. Box 785 Sonoca 95370	(209) 532-4534	Standard Oil	
2. J	Phillips Pet. Chase Bros.	P.O. Box 1116 Sonora 95370	(209) 532-4327	IRA Chase (209) 966-3314	
3. A	Mobil Oil Corp. L. Ramassa	P.O. Box 565 Sonora 95370	(209) 532-4191	- - - - -	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF TUOLUMNE

		Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		
Plant No.	Gasoline Thruput Gal/day(1/d)	Above or Under Ground	No.	Total Capacity Gal.(1) x 10^{-3}	Flow Rate GPM(1/m	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	Remarks
1.	6,000(23K)	A	4	73(276)	200	No	T	No	3	Yes	20	60	20% Commercial
2.	2,000(7.6K)	A	3	52(197)	100	- -	- -	- -	1	Yes	70	20	
3.	3,500(13K)	A	3	45(170)	100	Yes	T	-	2	Yes	0	75	25% Commercial

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN DIEGO

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
1 J	El Capitan Oil Co. Bob Sinclair	11427 Woodside, Lakeside 92040	(714) 448-5891	Ted Larsen	Do not have vapor recovery at this time. They are operating under a variance from FEA. Have plans to install vapor recovery.
2 J	Fallbrook Oil Lee Traut	1208 S-Main St. Fallbrook	(714) 728-7703		
3 J	Inland Oil Eric Kroesche	1726 W. Mission Road Escondido 92025	(714) 745-7723		
4 A	Clarence Ochs Oil (Texaco Consignee)	145 Via Vera Cruz, San Marcos 92069	(714) 744-5441		
5. J	Paine Oil Co - C.E. Land	420 East Vista Way Vista 92083	(714) 726-0370		
6. J	Ramona Oil - Bill Grove	1000 Olive Ramona 92065	(714) 789-0410		
7. J	Seashell Oil & Chemical R.L. Stier	423 No. Cleveland Oceanside 92054	(714) 722-2266		
8. J	Shuster Oil & Chemical - Bob L. Shuster	635 W. 3rd, Escondido 92025	(714) 745-0591		
9. A	Standard Oil -W.R. Lewis	321 South Quince , Escondido 92025	(714) 745-6922		
10. J	Valley Center Oil Gene LeBecke	28010 Valley Center Valley Center	(714) 749-1281		
11. J	Apollo Oil Bob Dyar	4401 Twain Ave San Diego 92120	(714) 280-6884		Pipeline Station only, no bulk plant

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN DIEGO (cont)

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
12 J	Barnicle Oil Co. Dean Barnicle	3525 Estudillo El Cajon 92022	(714) 295-4141	Greg Barnicle	Diesel only - Close down gas operation because of V.R. Costs
13 J	Bay Oil C.W. Noe	834 W. Grape Street San Diego 92101	(714) 234-2189	- -	Pipeline only - Stopped gasoline because of vapor recovery costs
14 J	Exclusive Transport & Pepper Oil Company David M. Pepper	2300 Tidelands Ave. National City 92050	(714) 477-9338	- -	Pipeline only - No longer handles gasoline because high vapor recovery costs
15 J	Fogerty Oil George Fogerty	946 W. Hawthorn San Diego 92101	(714) 234-5119	- -	Diesel & Solvent only. Gets gas at Exxon Terminal
16 J	Neptune Oil Co. Jack Donasky	9950 Mission Gorge San Diego 92120	(714) 282-2143	- -	Pipeline station only
17 J	Swain Oil Co. A.S. Swain	4435 Glacier Ave. San Diego 92120	(714) 280-4133	- -	Pipeline station only

J - Jobber

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF SAN DIEGO

Plant No.	Gasoline thruput Gal/day(l/d)	Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal.(l)	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	1000 (4K)	A	1	6700 (25K)		No	T	No	2	Yes	0	100	
2	2700 (10K)	U	2	16000 (61K)		Yes	T	No	2	Yes	75	25	Have Environics unit but does not work -
3	6700 (25K)	U	3	36000 (136K)		Yes	B	Yes	3	Yes	35	65	Has 2 non-operating Environics units
4	11000 (42K)	U	3	36000 (136K)	90 (340)	Yes	B	Yes	3	Yes	55	45	Have non-operating Environics unit
5	2700 (10K)	U	2	12500 (47K)	270 (1020)	Yes	B	Yes	2	Yes	50	50	Uses pump on truck to pump gasoline out of underground tank.
6	670 (3K)	U	2	18000 (68K)	45 (170)	Yes	B	Yes	1	Yes	95	5	Have non-operating Environics unit.
7	670 (3K)	A	1	25000 (95K)	287 (1090)	Yes	T	No	2	Yes	50	50	Are going to bottom loading on rack. Have Environics unit but does not work.
8	2000 (8K)	A	2	50000 (189K)		Yes	B	Yes		Yes	85	15	Have Environics unit, does not operate.
9	17000 (64K)	A	5	83000 (314K)	250 (950)	Yes	B	Yes	4	Yes	25	75	Refrigeration system.
10	1200 (5K)	U	3	21950 (83K)	45 (170)	No	T	No	1	No	100	0	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Adams, CO.

Plant No.		Plant Identification	Address	Telephone No. (303) Area Code	Source of Information	Future Plans
1	J	Harpel Oil-Chevron	5480 Brighton Commerce City	893-0017	J. Harpel	
2	J	Offen Texaco	5400 Brighton Commerce City	825-1434	Mr. Offen	
3	J	Riggi Oil	6795 Brighton Commerce City	288-5739	J. Riggi	
4		Adams County Co-op Farmland	700 block, N. Main Brighton	659-1230	A. Shivley	
5	A	Conoco Bulk Plant	500 block, N. Main Brighton	659-4244	J. Phillips	
6	J	Greene Bros. - Phillips	Hwy. 85, Brighton	659-3380	J. Eachus	May close
7	J	Reed Oil - Mobil	500 block, N. Main Brighton	659-1806	S. Reed	May move
8	A	Std. Amoco	6385 E. 80th, DuPont	287-8021	M. Buckley	Essentially shut down
9	A	Std. Oil - Amoco	501 N. Main, Brighton		B. Prather	Only diesel
10	J	Rapp Oil	575 S. 4th Ave. Brighton	659-1993	K. Rapp	Plant closed

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Adams

Plant No.	Max. Gasoline thruput Gal/day(l/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(l)x10^3	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	3,000 (11K)	U	2	38 (144	75 (285)	--	Top	--	2	--	50	0	
2	7,000 (26K)	A	4	47 (179	100(380)	--	Top	--	3	--	35	2	
3	2,000(7.6K)	A	1	12 (45)	35 (130)	Yes	Top	--	1	--	90	-	
4	6,000 (23K)	A	3	45 (170	160(600)	No	Top	No	2	--	85	0	Loads at 200 GPM
5	3,500 (13K)	A	3	40 (151	100(380)	No	Top	--	2	--	90	-	
6	5,000 (19K)	A	1	12 (45)	40 (150)	Yes	Top	--	1	--	100	-	
7	10,000 (38K)	A	4	23 (87)	60 (230)	No	Top	No	1	--	95	-	
8	--	-	-	--	--	--	--	--	--	--	--	-	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Arapahoe, CO.

Plant No.		Plant Identification	Address	Telephone No. (303) Area Code	Source of Information	Future Plans
1	J	Bartlett Oil	4950 Santa Fe, Littleton	794-7888	W. Bartlett	
2	J	Diamond Gas & Fuel-Fina	4101 Santa Fe, Englewood	761-0990	R. Lucero	
3	J	Duggan Petroleum	5240 Santa Fe, Littleton	798-8453	P. Duggan	
4	J	Merchants Oil	Aurora	733-4627	G. Caulkins (Denver)	

J-Jobber

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Arapahoe

Plant No.	Gasoline thruput Gal/day(1/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(1)x10^3	Flow Rate GPM(1/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	15,000(57K)	A	8	47 (177)	140(530)	Planned	T	--	1	--	0	100	
2	10,000(38K)	A	4	39 (148)	60(230)	Planned	T	No	4	95%	5	70	
3	<5,000(<19K)	U	4	56 (212)	200(760)	Planned	T	No	1	Yes	50	0	
4	- - -	- -	-	- - -	- - -	- -	- -	- -	-	-	- -	- -	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Boulder, CO.

Plant No.	Plant Identification	Address	Telephone No. (303) Area Code	Source of Information	Future Plans
1 J	Venta, Inc. - Gulf	Hwy 287 & Dillon Rd. Broomfield	466-1460	M. Marris	
2 J	Bartkus Oil - Mobil	3501 Pearl, Boulder	442-6000	T. Bartkus	
3 A	Conoco Bulk Plant	3200 Pearl, Boulder	442-1393	J. Jameson	
4 A	Chevron-Thomas Oil	4898 Pearl, Boulder	444-4171	D. Meachem	
5	Shamrock	49th St. & Pearl Boulder			
6 A	Amoco Oil Co. - Std. Oil	3101 Pearl, Boulder	442-3634	J. Simpson	
7 J	Burger Bros.-Texaco	10 Main St., Longmont	776-0743	J. Piper	To be Star Oil
8 J	City Oil & Fuel Chevron	275 Third Ave., Longmont	776-1572	W. Spallinger	
9	Co-op - Farmland	72 E. 2nd St., Longmont	776-5015	M. Jansen	
10 J	Johnson's Corner - Husky	Diagonal Hwy & S. Main Longmont	688-5337	C. Prescott	
11 J	Longmont Propane Service - Shamrock	Hwy 66 & Main, Longmont	443-4145	B. Slieker	
12 J	Lang Oil Co. - Phillips 66	1005 Main, Longmont	776-3193	G. Lang	
13 J	Yoakum Oil & Tire	45 S. Main, Longmont	893-0418	H. Yoakum	
14 J	Beasley Oil	Lafayette	665-3363	K. Schewbert	
15 J	George Oil Co.-Amoco	P.O. Box 218, Lafayette	665-9976	B. Prather	
16 J	Louisville Oil Phillips 66	701 Main, Louisville	666-6528	K. Schewbert	
17 A	Conoco Bulk Plant	431 4th Ave., Lyons	823-6865	R. Cink	
18 A	Standard-Amoco	10 Main St., Longmont	442-3634	J. Simpson	
19 J	Luckett Oil	Boulder	--	--	Shut down
20 J	J & R Service	11 Ave. & Main, Longmont	--	--	Plant phased out
21	Sinclair	Boulder	- -	- -	Shut down

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Boulder, CO.

Plant No.	Plant Identification	Address	Telephone No. ( ) Area Code	Source of Information	Future Plans
22	Berthoud Oil - Exxon	4 S. Main, Longmont	- -	- -	
23	Fina	Longmont	- -	- -	Closed
24	Gulf	Longmont	- -	- -	Closed
25	Conoco	Longmont	- -	- -	Closed

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Boulder

Plant No.	Gasoline thruput Gal/day(l/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(l)x10^3	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	2,000(7.6K)	A	5	59(223)	60 (220)	No	T	No	1	--	50	0	
2	10,000 (38K)	A	6	75(284)	90 (340)	Planned	T	--	3	Yes	3	90	
3	3,500 (13K)	A	5	75(284)	200(760)	Yes	B	Yes	2	Yes	5	75	
4	6,000 (23K)	A	3	42(159)	100(380)	--	T	--	1	--	5	95	Unload at 100 GPM
5	--	A	3	--	--	--	T	--	1	--	-	--	
6	13,500 (51K)	A	3	43.5 (165)	250(950)	--	T	--	2	Yes	-	70	Outgoing at 100 GPM
7	--	-	-	--	--	--	-	--	-	--	-	--	
8	3,000 (11K)	A	5	31(117)	60 (220)	No	T	No	1	--	60	--	
9	4,000 (15K)	A	2	18 (68)	50 (190)	No	T	--	1	--	95	--	
10	--	-	-	--	--	--	-	--	-	--	-	--	
11	<1,000 (<3.8K)	A	4	15 (57)	60 (220)	--	T	--	1	--	100	--	
12	2,000(7.6K)	A	4	32(121)	150(570)	Planned	T	--	1	--	80	0	Outgoing at 80 GPM
13	1,500(5.7K)	A	4	12 (45)	--	--	-	No	1	--	100	0	
14	<1,000 (<3.8K)	U	5	18 (68)	50 (190)	In process	T	No	1	--	90	0	
15	1,600(6.1K)	A	3	25 (95)	200(760)	--	T	--	2	--	0	100	Outgoing at 125 GPM
16	<1,000 (<3.8K)	A	2	32(121)	75 (280)	--	T	--	1	--	100	0	
17	3,000 (11K)	A	3	41(155)	50 (190)	--	T	--	2	--	90	3	
18	1,600 (6K)	A	4	44(166)	250(950)	--	T	--	1	Yes	-	33	Outgoing at 100 GPM

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Denver, CO.

Plant No.	Plant Identification	Address	Telephone No. (303) Area Code	Source of Information	Future Plans
1 A	Chevron - Barlow	5201 E. 48th Street	399-2070	G. Barlow	No change
2 J	Colorado Petroleum	4080 Globeville Rd.	825-7104	T. Thompson	
3 J	Green Bros.-Chevron	5335 Harrison	623-5195	Mr. Green	
4 J	Merchants Oil	105 S. Cherokee	733-4627	G. Caulkins	
5 J	Midway Gas & Oil - Texaco	1345 W. Bayaud	733-4679	S. Freehling	
6 J	Rex Oil - Conoco	5598 Broadway	222-6701	G. Balenseifen	
7 J	Riddell Petroleum	899 Decauteur	825-8117	Mr. Riddell	
8 J	Sales Oil	5435 E. Pacific	777-8948	Mr. Sales	
9 J	Siegel Oil	1380 Zuni St.		A. Siegel	
10 J	Sam Hill Std-Amoco	501 W. 45th St.	433-3319	S. Hill	
11 J	Kelly Std-Amoco	875 Navajo	534-0351	T. Kelly	
12 J	Climax Oil Co.	1665 West Evans	- -	- -	
13 J	Home Oil & Supply	West 12th Ave.	- -	- -	
14 J	Hensley Oil				Closed
15 J	Husky Oil Co.	5125 York			Closed
16 J	Maddox Oil Co.	Del Norte St.	288-2681	E. Maddox	No plant
17 J	Mapleton Sales	5755 Washington	255-5481	A. Domenico	No plant
18 J	Sav-o-mat	- -	744-1711	- -	No plant
19 J	Silco Oil Co.	2065 W. Colfax	825-1361	- -	No plant

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Denver

Plant No.	Gasoline thruput Gal/day(l/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(l)x10^3	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	1,500(5.7K)	A	2	34 (128)	200(760)	Planned	T	--	2	--	0	0	100% small commercial customers
2	6,000 (23K)	U	2	50 (189)	100(380)	Planned	T	--	2	--	0	50	Converting trucks to bottom loading
3	3,000 (11K)	U	4	40 (151)	60 (230)	Yes	T	--	2	--	0	0	100% commercial customers
4													
5	12,000(45K)	A	3	51 (193)	80 (300)	Planned	T	Planned	3	--		60	
6	10,000(38K)	A	3	36 (136)	100(380)	Planned	T	--	1	--	5	35	
7	<1,000 (<3.8K)	U	3	36 (136)	200(760)	No	T	No	1	--	0	1	
8	<1,000 (<3.8K)	A	2	39 (146)	100(380)	Yes	T	No	1	--	0	0	
9	10,000(38K)	U	2	40 (151)	--	Planned	B	Planned	2	--	0	0	
10	10,000(38K)	A	4	28 (106)	250(950)	Planned	T	Planned	5	Yes	-	15	
11	9,000 (30K)	U	4	34 (128)	100(380)	--	T	--	2	--	-	17	
12	-	-	-	-	-	-	-	-	-	-	-	-	
13	-	-	-	-	-	-	-	-	-	-	-	-	

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Jefferson, CO.

Plant No.	Plant Identification	Address	Telephone No. (303) Area Code	Source of Information	Future Plans
1 J	Clear Creek Oil - Amoco	Exit 59, Hwy. 40, Golden	279-2127	S. Olhausen	
2 A	Conoco Bulk Plant	210 Depot, Golden	279-6363	J. Bonham	

J-Jobber
A-Agent

SMALL GASOLINE BULK PLANT INVENTORY, COUNTY OF Jefferson

Plant No.	Gasoline thruput Gal/day(l/d)	Gasoline Storage Tanks			Incoming Loads		Outgoing Load				Customers - %		Remarks
		Above or Under Ground	No.	Total Capacity Gal(l)x10^3	Flow Rate GPM(l/m)	Vapor Recovery	Top or Bottom Load	Vapor Recovery	No. Trucks	Sub. Fill	Small Agricultural	Service Station	
1	1000 (3.8K)	A	3	21 (79)	Gravity Feed	No	T	No	1	--	20	50	
2	4000 (14K)	A	5	60 (230)	60 (230)	--	B	--	2	--	10	50	

APPENDIX B

SAMPLE TELEPHONE CHECKLIST

APPENDIX B INFORMATION CHECKLIST

The appended checklist was used in the telephone survey. Telephone survey was conducted only when data from other sources of information was inadequate. Pertinent information and that which was readily available are presented in Appendix A. Information which was found not to be easily available (with only a few scattered inputs) and not to be of significant importance to the inventory was omitted from Appendix A. Section 3 utilizes all the data to describe a typical bulk plant. Other information not tabulated in Appendix A are presented in the sections of the report in which they are utilized.

SMALL BULK PLANT EVALUATION

1. Owner Operator ______________________________

   Location ______________________________

   ____

   Contact __________________________ Phone (   ) ________________________

2. Max. Daily Gasoline Throughput ______________ gallons

3. No. of Underground Gasoline tanks __________

   Capacities ______________ gallons

4. No. of Aboveground Gasoline tanks __________

   Capacities ______________ gallons

5. Tank Fill Line Size ______ in., Length ______ Ft.

6. Top Loading Rack Line Size _______ in., Length _______ ft.

7. Bottom Loading Rack Line Size _____ in., Length ______ ft.

8. Tank Accessories

   Vent Line Size ________ in., Flame Arrestor? _____

   Relief Valve Setting ________ lbs

   Pump Size ___________ GPM

   Submerged Fill ______________ inches from bottom

9. Supply Vehicle(s)

   Capacity __________ gallons, No. of compartments _______

   Couplings ______ Screw ________ Latch _______

   Shut-off Valve _______ Vapor Return Line Size ________

10. Delivery Vehicle(s)

    Capacity _________ gallons, No. of compartments _______

    Time to Fill _____ minutes

    Submerged Fill? __________

11. Vapor Recovery. Delivery Vehicle

Date installed __________ By whom ____________

Cost ______________

Bottom or Top Load ______________

Operating Problems ______________

12. Vapor Recovery Storage Tank/incoming loads

Date installed ___________ By whom ___________

Cost ______________

Operating Problems ______________

13. Vapor Recovery, Storage Tank/Loading Rack (Delivery)

Installed __________ By whom ____________

Installation Cost __________, Operating Cost ______________

Maintenance Cost ____________

Operating Problems _____________

14. Vapor Recovery, Delivery Vehicle

Installed __________ By whom __________

Installation Cost __________ Operating Cost ___________

Maintenance Cost __________

Operating Problems __________

15. % Deliveries to Exempt Customers ________

APPENDIX C

(ACKNOWLEDGEMENTS FOR ASSISTANCE IN OBTAINING INFORMATION)

1. Local Air Pollution Control Agencies

P. Venturini, D. Simeroth and P. Ouchida, California Air Resources Board, Sacramento, CA

J. Talbot, G. Karles, Bay Area Air Pollution Control District, San Francisco, CA

E. Tronco, Air Pollution Control Division, Colorado Department of Health, 4210 East 11th Avenue, Denver, CO 80220

R.L. Batten, Air Pollution Control District, County of San Diego, 9150 Chesapeake Drive, San Diego, CA 92123

R. McCauley, Merced County Department of Public Health, a10 East 13th Street, Merced, CA 95340

J. Thompson, Mariposa County Air Pollution Control District, P.O. Box 5, Mariposa, CA 95338

G. Gurley, Madera County Air Pollution Control District, 135 West Yosemite Avenue, Madera, CA 93637

Mr. Kerstan, Tulare County Air Pollution Control District, Health Building, County Civic Center, Visalia, CA 93277

J. Kancher, Fresno County Department of Health, Environmental Health Services, 1246 L Street, Fresno, CA 93721

C. Smith, Amador County APCD, 810 Court Street, Jackson, CA 95642

E. Bigelow, APC Officer, Tuolumne County APCD, County Courthouse, 9 North Washington Street, Sonora, CA 95370

T. Goff, Kern County APCD, 1700 Flower Street, Bakersfield, CA 93302

P. Gregg, Kings County APCD, 1221 West Lacey Boulevard, Hanford, CA 93230

J. Spano, San Joaquin County APCD, 1601 East Hazelton Avenue, Stockton, CA 95201

W. Morgan, APC Supervisor, Stanislaus County APCD, 1213 14th Street, Modesto, CA 95354

T. Garamendi, Calveras County APCD, Government Center, El Dorado Road, San Andreas, CA 95249

2. Major Oil Company Sources

W.L. Warrick, Manager, Bulk Plant Analysis Products Division,
515 South Flower Street, Los Angeles, CA 90051

Z. Brown, Texaco, Inc., 3350 Wilshire Boulevard, Los Angeles,
CA 90010

A.W. Percy, Union Oil Company of California, Union Oil Center,
Los Angeles, CA 90017

E.L. Bass, Standard Oil of California, P.O. Box 6000, Sacramento,
CA 95860

Mr. Haggermeyer, Chief Engineer, Exxon Company USA, 1800 Avenue
of the Stars, Los Angeles, CA

3. Industry Association Sources

M.N. Williams, Petroleum Equipment Institute, 1579 East 21st Street,
Tulsa, OK 74114

E. Kroesche, President, California Oil Marketers Association,
Inland Oil Company, 1726 W. Mission, Escondido, CA 92025

Mr. Gubrud, American Petroleum Institute, 2101 L Street N.W.,
Washington, D.C. 20037

C. Houston and Mr. Bassman, National Oil Jobbers Council,
1750 New York Avenue, Washington, D.C. 20066

4. Safety Related Sources

Capt. D. Kennerson, Fire Prevention Bureau, 4761 E. 69th Street,
Commerce City, CO 80022

Capt. C. McDonald, California Fire Prevention Committee Chairman,
Long Beach Fire Department, Long Beach, CA

Underwriter Laboratories, 333 Pfingsten Road, Northbrook, IL

J. Koons, Factory Mutual Insurance, Boston, MA

J. Paul, California State Fire Marshall, Sacramento CA

M. Woodworth, National Fire Protection Association, Boston, MA

E. Kunkle, Industrial Insurers, 6055 East Washington Boulevard,
Los Angeles, CA

5. Miscellaneous Sources

S. Bleich, Approved Engineering Test Laboratories,
5320 West 104th Street, Los Angeles, CA 90045

Mr. Dixon, L.A. County Assessor, 500 West Temple, Los Angeles, CA

B. Canfield, Fresno County Assessor, 2281 Tulare Street, Fresno, CA

Mr. Deckard, Evans Trucking, Maywood, CA

Mr. Holt, Oilfields Trucking Co., 20425 South Hamilton Street,
Torrance, CA

B. Gregg, Oil Daily, 416 West 8th Street, Los Angeles, CA

M. Emond, National Petroleum News, McGraw Hill, 3200 Wilshire Boulevard,
South Tower, Los Angeles, CA 90016

APPENDIX D

CONTRACTOR COST DATA

Table D-1. CONTRACTOR COST DATA FOR VAPOR RECOVERY ON INCOMING LOADS

Company	Phone Contact	Tanks	Tanks	Equip. Cost (%)	Relief Valve	
		Above Ground ($)	Underground ($)		Press. oz/in^2	Vac. oz/in^2
Petroleum Eng. Co. Santa Rosa	(707) 545-0366 Don Marshall	4,000 - 18,000 (Avg. 3,000/tank)	300 - 1,500	40		
Haehl Equip. Co.	(209) 268-7883 Willy Garcia	-	-	-	8	0.5
Bill's Service Station	(209) 632-6370 Bill	900	-	60	-	-
McAlpine Const.	(213) 634-1161 Ed Sybil	3,000 - 6,000 (Typical = 3,200)	200	60	5 - 8	-
C. E. Thomas	(213) 321-8420 Ted Reynolds	2,000 - 3,000	-		-	-
Gardoil	(209) 935-1123 O'Neal	2,000	-	40	4 - 8	-
Fhemco	(209) 688-2977 Bob Hill	1,700 - 4,700 (Typical = 2,400)	-		8	1
Curb Service	(209) 485-6690 F. Staffero	4,500 - 5,000	-		-	-
J-8 Equipment Denver	(303) 222-9495 Dean Woods	-	-		-	-
PSI Equipment Sales Fresno	(209) 233-2656 Art Benjamin	800 - 5,500 (Typical = 1,500)	700 - 1,000		2	-
Staiger Const. Fresno	(209) 233-4606 Bill Johnson	4,500 - 8,500 (Typical = 6,000 to 7,000)	650/Tank		5 - 8	-
Ryan Petroleum Colorado Springs	(303) 424-9419 -	800 - 6,000 (800 - 1,000/Tank)	600/Tank	40	8	-
MJB Plumbing	(209) 237-5686 Marty	2,500 - 5,100	-	50	9 - 11	-
Stockton Service Station	(209)464-8333	2,000 - 5,000	-	35	10 - 12	-

Table D-2

CONTRACTOR COST DATA FOR VAPOR RECOVERY ON INCOMING AND OUTGOING LOADS

Contractor	Phone Contacts	Storage Tank Locations		Equip. Cost (%)	Relief Setting (oz/in^2)	Comments
		Above Ground ($)	Underground ($)			
McAlpine Const.	(213) 634-1161 Ed Sybil	-	6,000 - 7,000 Plus Island	-	-	
Fhemco	(209) 688-2977 Bob Hill	8,000 Plumbing only	-	-	-	
J-8 Equipment Denver	(303) 222-9495 Dean Woods	6,000 - 7,000 No Mods. to Truck	6,000 - 7,000	-	-	Top Loading
Staiger Const. Fresno	(209) 233-4606 Bill Johnson	-	-	-	-	
Terra & Weaver	(408) 292-6294 Mr. Terra	33,000	33,000	40	-	$20,000 to convert tanks from above-ground to underground
Midwest Equip. Co.	(303) 744-6386 Gus Gossett	-	4,500	81	8	Revised top to bottom load in new facility
MJB Plumbing	(209) 237-5686 Marty	5,500 Plumbing only	-	-	9 - 11	
PSI Equipment Sales Fresno	(209) 233-2656 Art Benjamin	11,500 (Top Loading) 21,500 (Bottom Loading)	-	-	-	
Stockton Service	(209) 464-8333	65,000 - 85,000	-	-	-	Top to Bottom Loading

Notes: Values for plumbing only and less island were not used in averages

Table D-3. CONTRACTOR COST DATA FOR VAPOR CONTROL ON TRUCKS

Name	Phone Contact	Incoming Truck Trailer Per 4 Compartments ($)	Account Trucks Having 4 Compartments ($)	Vapor Recovery Only ($)	Pressure/Vacuum Valve Set Point	Remarks
Fruehauf Corporation Fresno	(209) 442-881	TYP 1400 (350/comp) Range 150 to 1000/comp	TYP 4000 (1000/comp) Range 150 - 1000/comp	Within Range	-	-
Openshaw Modesto	(209) 537-2212 Bernard	4000 Typical	4000 Typical	1,500 - 1,700	-	Aluminum Trucks will cost more
B & G Machine	(805) 322-7764	2,500 - 3,750 Average Range 2,500 - 7,500	2,500 - 3,750 average Range 2,500 - 7,500	2,000 - 3,000 Range 2,000 - 6,000	- -	-
EDECO-West Fresno	(209) 485-0670	7000	-	1800 (incoming)	-	New delivery truck $8,000
Clough, Inc. Seattle	(206) RO-3-2222 H. Lagnin	4,500 Typical Range 3,500 to 5,500	-	-	-	-
Clough, Inc. Sacramento	(916) 371-7807 Bill Judd	6,800 Typical Range 6,000 to 8,500	6,400 Typical	-	22 inches of H_2O (required by San Diego)	New incoming trucks cost is $30,000
Merritt Tank Lines Berkeley	(415) 525-3206 Ron Bise	Range 8,000 to 10,000	Range 6,000 to 7,000	4,000 to 5,000 (incoming)	22 inches of H_2O 13 inches of H_2O 10 inches of H_2O	Different ranges required by different customers
PSI Equipment Fresno	(209) 233-2656 Art Benjamin	-	4,000 Typical	-	-	-

APPENDIX E

APPLICABLE
VAPOR CONTROL REGULATIONS

APPENDIX E

APPLICABLE VAPOR CONTROL REGULATIONS

The presence of vapor control systems in bulk plants was primarily a response to applicable local regulations. A summary and comparison of applicable Environmental Protection Agency (EPA) regulations and local regulations are presented in Table E-1.

Bulk plant EPA regulations applicable to the specified areas differ from state and local regulations primarily in the area of exemptions. The EPA bulk plant exemptions apply to: (1) tanks with floating roofs and (2) facilities that provide exclusive service to exempt accounts. Exempt accounts are defined as accounts with tanks (1) with less than 7,570 liters (2,000 gallons) capacity existing prior to promulgation of regulations, (2) with less than 950 liters (250 gallons) capacity and (3) with less than 2,080 liters (550 gallons) capacity for exclusive husbandry use.

The corresponding California bulk plant exemption is an annual petition provision for bulk loading delivery facilities with an annual throughput of 500,000 gallons or less, provided that the delivery vehicles are loaded through a submerged fill pipe. Floating roof tanks are not exempted.

Other California state and local differences affect areas of applicability, definitions of minimum vapor control process and equipment, schedules of compliance, and stationary gasoline tank exemptions.

Denver metropolitan regulations also differ from EPA regulations The state "bulk plant" exemption is for facilities that load delivery vehicles serving exempt users and which have a maximum daily throughput of 76,000 liters (20,000 gallons). Other differences involve definitions of product, minimum process control and equipment, and stationary tanks size exemption.

Table E-1. APPLICABLE BULK PLANT GASOLINE VAPOR CONTROL REGULATIONS

Item	EPA (52.225,Rev.2/76 & 52.336, 2/74)	ARB* (Suggested Rules, 4/75, Specified APCD's)	ARB** (Suggested Rules, 4/75, Specified APCD's)	SAN DIEGO 9/74	DENVER (Colorado Reg. 7, 12/75)
AREA AFFECTED	L.A. Metro.,Sacto. Valley San Joaquin Valley, & Metro. Denver AQCR's	Generally urban APCD's	Generally rural APCD's	County	Denver Metropolitan
GASOLINE DEFINED	R.V.P. ≥ 4 pounds	R.V.P. ≥ 4 pounds	R.V.P. ≥ 4 pounds	V.P. ≥ 1.5 psia	V.P. ≥ 1.5 psia
DEGREE OF CONTROL REQUIRED	90%,by wt., of organic compounds in displaced vapors	90%,by wt., of organic compounds in displaced vapors & entrained liquid	90%,by wt., of organic compounds in displaced vapors & entrained liquid	90%,by wt., of enterin. vapors +0.1% , by vol., leak at any point	≤1.24 lbs/1000 gal. loaded in vehicle & ≤1.15 lbs/1000 gal. loaded in tanks.
TANK FILL PIPE	Submerged	Permanent submerged		Submerged	
DELIVERY VEHICLE FILL PIPE		Submerged for exempt equipment			97% submerged for exempt equipment
MIN. CONTAINER SIZE(GAL)	> 250	>250	>40,000 or >20,000 gal. daily throughput	> 550	> 550
HARDWARE REQUIREMENTS	Preclude transfer prior to vapor tight return connection and adaptable to mech. system retrofit mech. system to be refrig. condensation or equal	Pressure vacuum valve on above-ground tanks	Collect "all vapors" or adsorber/condensation system	Means to prevent draining at disconnect adsorption, absorption condensation or other	Preclude transfer prior to vapor line connect and amenable to mech. system retrofit. Connection to close when disconnected Vapor liquid absorber or equal mech. system
BULK PLANT EXEMPTION FOR VEHICLE FILLING	Exclusive exempt service (52.225 only)	< 500,000 gal. annual throughput may petition for annual exemption			Exclusive exempt service and <20,000 gal. daily throughput
FLOATING ROOF EXEMPTION	YES	NO	YES(for >40,000 gal) & NO (for >20,000 gal. daily throughput)	YES	
EXISTING TANK EXEMPTION PRIOR TO PROMULGATION OF REGULATION	<2,000 gal. capacity	≤2,000 gal capacity with submerged fill and all with offset and submerged fill		≤2,000 gal monthly throughput and submerged fill	≤2,000 gal capacity
HUSBANDRY EXEMPTION	<550 gal. capacity exclusive use	Primary use with submerged fill		Wind machine use	

* Typical of urban San Joaquin Valley AQCR County Regulations.
** Typical of mountain and rural San Joaquin Valley AQCR County Regulations